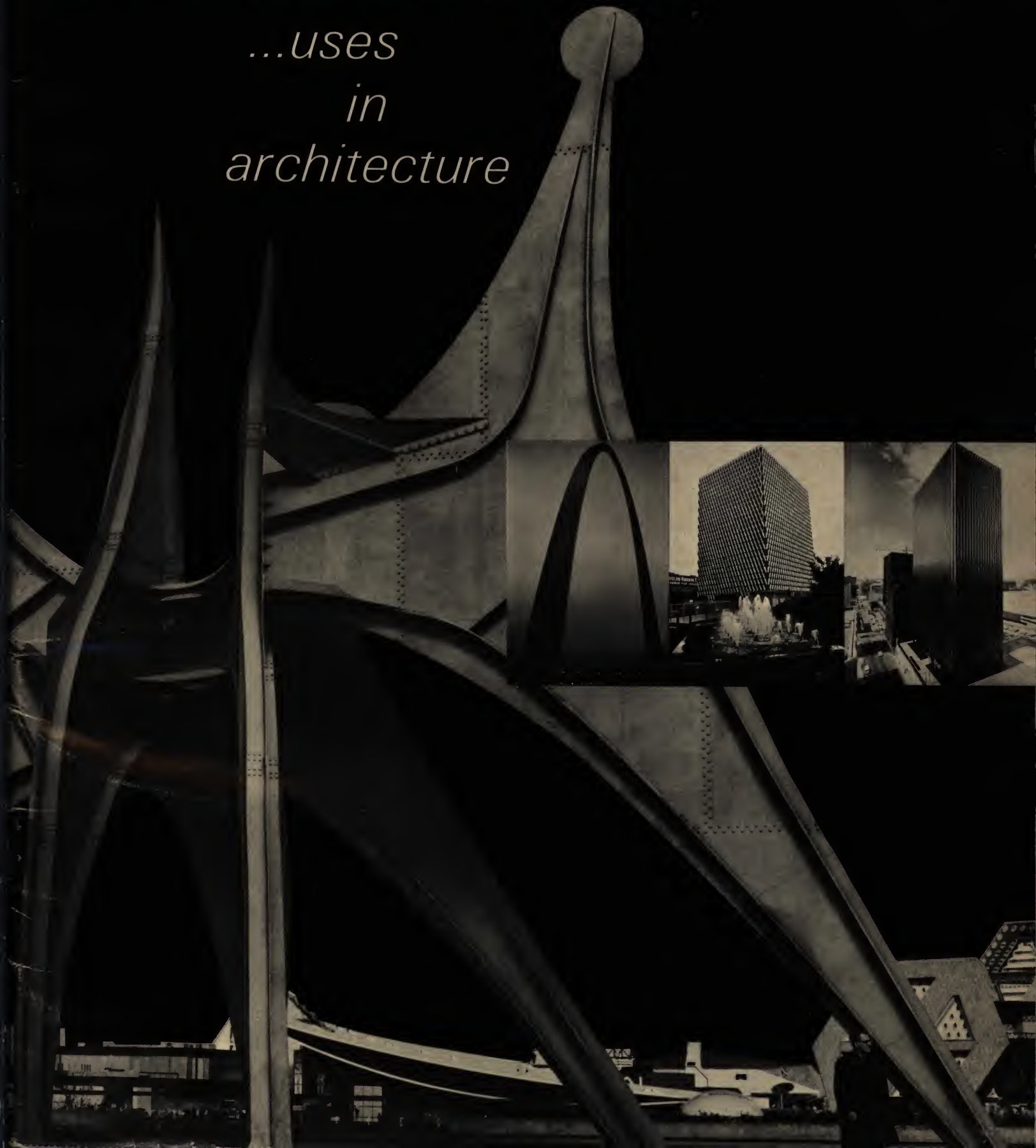


# STAINLESS STEEL

*...uses  
in  
architecture*





*FRONT COVER:* A dramatic variety of designs demonstrates the versatility and beauty of stainless steel. These include the St. Louis Arch, The IBM Building (Five Gateway Center), Pittsburgh, and the Osborn Building, St. Paul. They are pictured against a background of Alexander Calder's "Man" in Montreal.

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The Committee of Stainless Steel Producers wishes to acknowledge the following for their help in making this manual possible:

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Professor John Hancock Callender,  
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**Art Consultant:**

Barnet Edelman



# A. ARCHITECTURAL APPLICATIONS

Most architects recognize stainless steel as a quality material of unquestioned merit. It definitely is a contemporary material, but one that has been proved by extensive use both in and on buildings for nearly half a century. During the past ten years, these uses have increased tremendously. Once regarded as a luxury item, stainless steel's overall economy now is recognized widely, in functional as well as aesthetic applications.

Few architects, however, and very few students of architecture, are fully conversant with the unique characteristics and capabilities of stainless steel. In general, textbooks on building construction expound on the properties and usage of wood, masonry, concrete and structural steel, but say very little about the architectural metals.

Recognizing this information gap, this handbook has been prepared especially for architectural students, but also with the practitioner in mind, to provide a basic understanding of the nature and potential of stainless steel as a building material. It attempts to explain simply, in non-technical language, how the metal is produced and fabricated, and to show the many ways it is being used by leading architects. Textual material is generously illustrated.

The information is presented in two sections. The first illustrates a representative variety of architectural applications, ranging from hardware items to multi-storied curtain walls. The second part describes, by narrative and graphics, how stainless steel is produced; what the principal types and their properties are; and how the metal is cut, formed, assembled and finished. Suggestions are included on the design of stainless steel architectural components.

Although the specific concern is with stainless steel, the descriptions of the various manufacturing and fabricating processes generally also apply to other metals. There may be, among practicing architects as well as students, many who will find this information both interesting and useful.

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# DOORS AND ENTRANCES

*Textured stainless is used for flush doors at New York Telephone Company's long-lines center, New York.*

**ARCHITECTS:**  
*Kahn and Jacobs.*



*Graceful stainless steel revolving and narrow-stile swing doors at Illinois Bell Telephone Building, Chicago, are complemented by stainless steel mullions.*

**ARCHITECTS:**  
*Holabird and Root.*





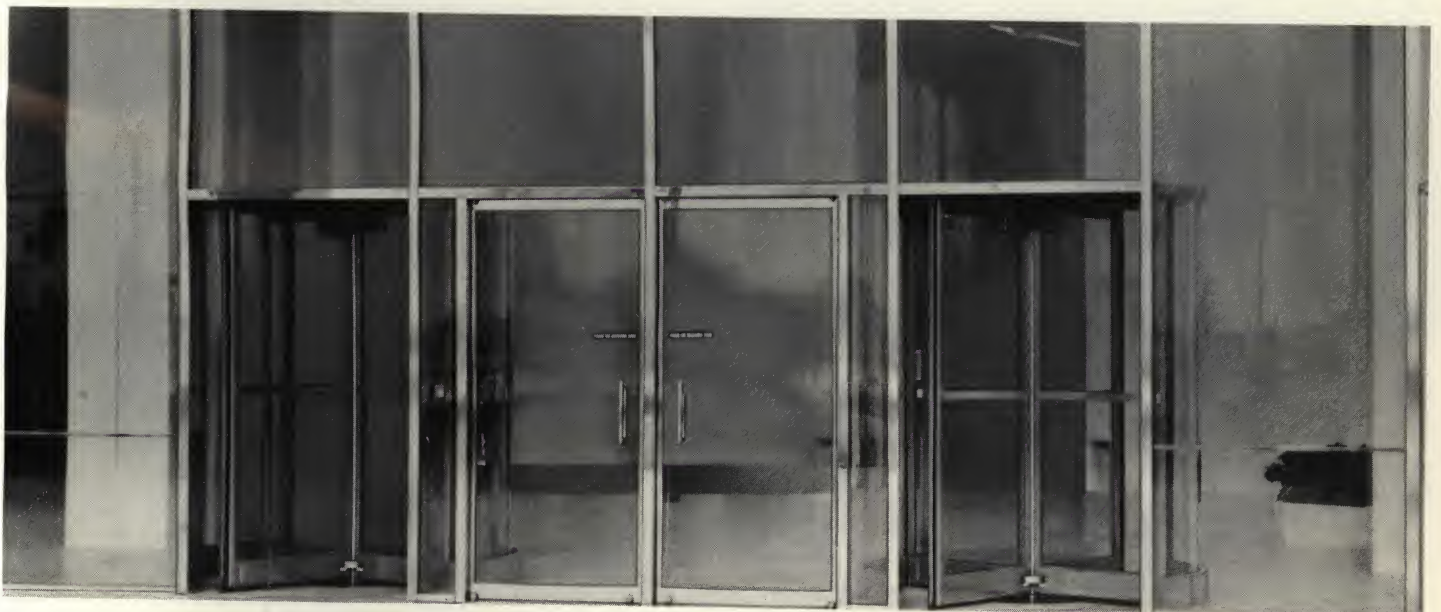
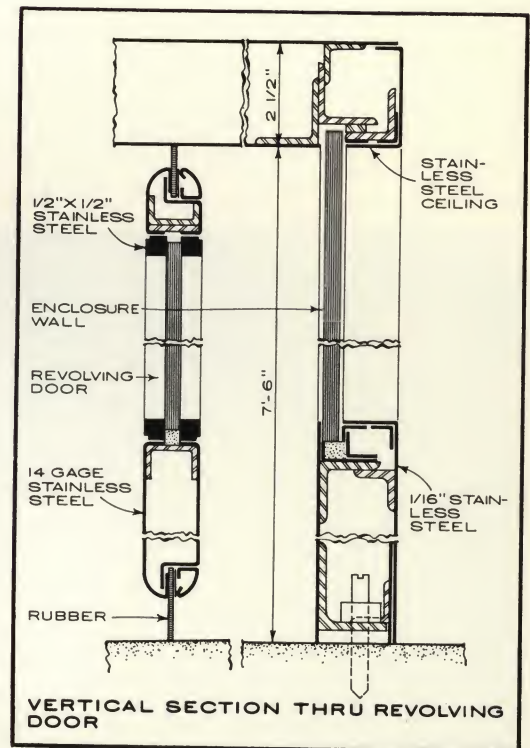


*Decorative glass doors, with stainless frame and door pulls, are installed at Kirkeby Center, Los Angeles.*

**ARCHITECTS:**  
*Claud Beelman & Associates.*

*Highly polished stainless steel is used for framing and entrance of Michigan Consolidated Gas Building, Detroit. Stainless also is used throughout the building, in the lobby and for window framing. Details are shown at right.*

**ARCHITECTS:**  
*Minoru Yamasaki—Smith,  
Hinchman & Grylls Associates.*



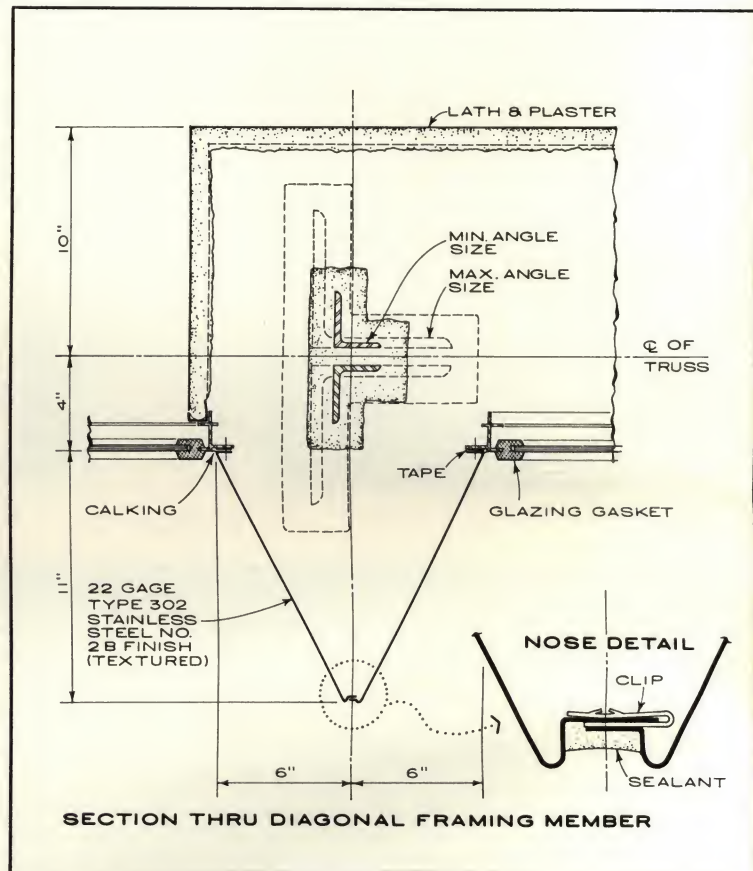


# HIGH-RISE WALL APPLICATIONS

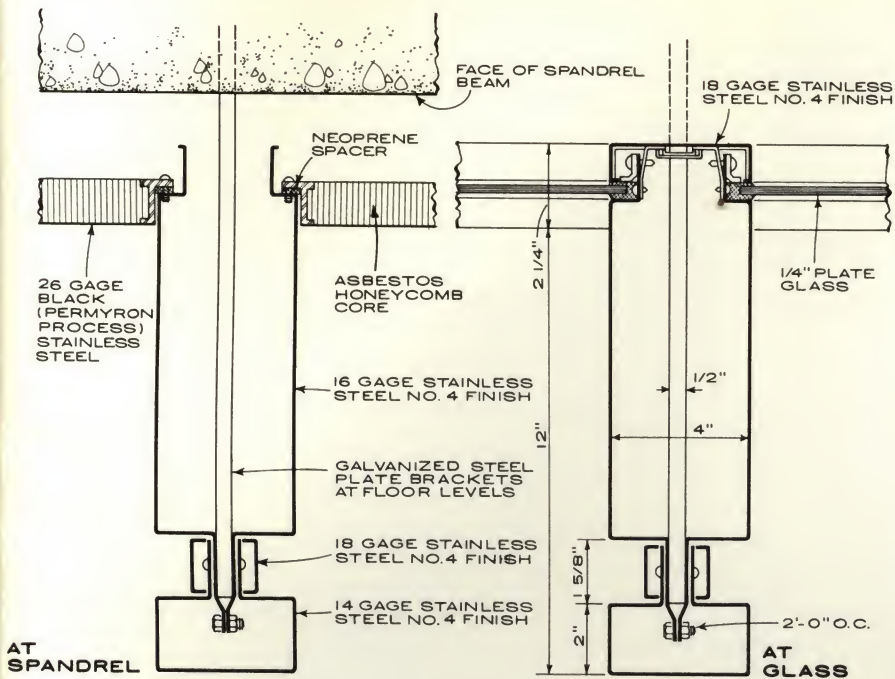


Latticed steel load-bearing wall of Gateway No. 5, Pittsburgh, is sheathed in stainless steel and serves both as frame and enclosing wall. Details are shown at right.

ARCHITECTS:  
Curtis and Davis.







PLAN SECTIONS OF VERTICAL EXTERIOR MULLIONS

Mullions, column covers, and 6,824 wall panels on the Union Carbide Building, New York, are stainless steel. Details are shown above photo.

ARCHITECTS:  
Skidmore, Owings and Merrill.

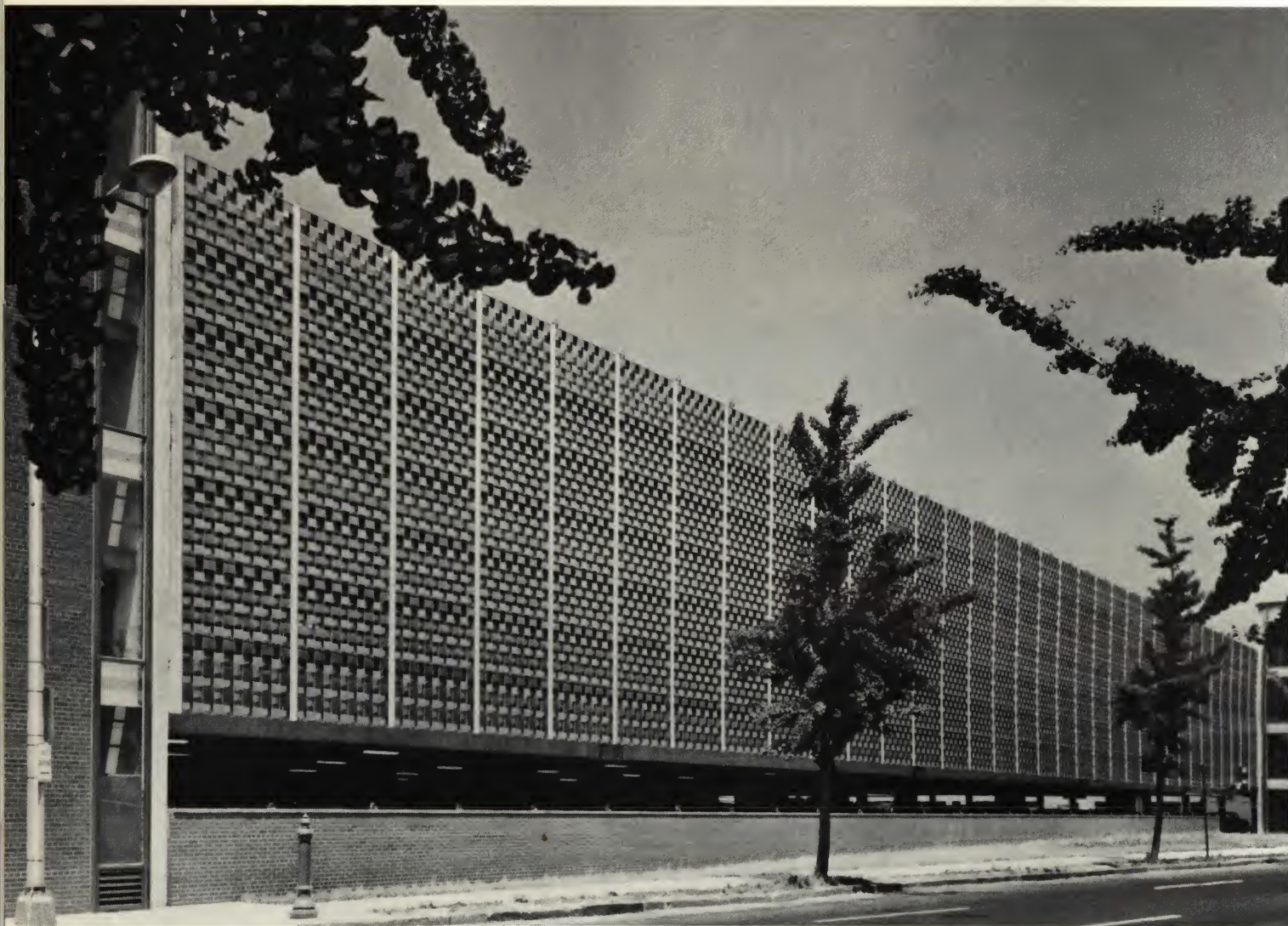


Windowless elevator tower of Pittsburgh's Public Safety Building features stainless exterior.

ARCHITECT:  
Alfred Marks.



# LOW-RISE WALL APPLICATIONS

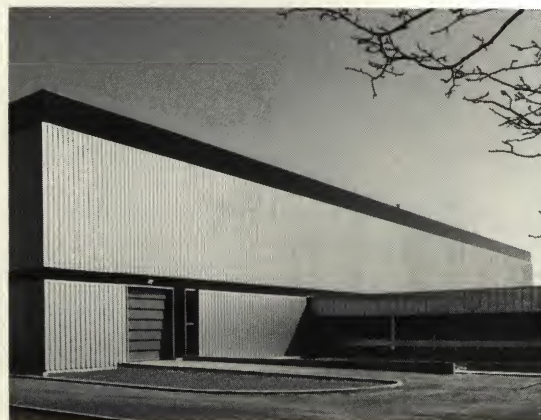


*Decorative screen of stainless steel enclosing Main-Martine Parking Garage, White Plains, New York, permits ventilation, while shielding headlight glare.*

**ARCHITECTS AND ENGINEERS:**  
*Abbott, Merkt and Company.*

*The architects and engineers of this stainless steel industrial building received a design award from the National Design Council of Canada.*

**ARCHITECTS:**  
*Bregman and Hamann.*







*Stainless sheathing was used  
for exterior columns at the Decatur  
Federal Savings and Loan Association,  
Decatur, Georgia.*

*ARCHITECTS:  
Fuller & Beckett.*

*Attractive stainless steel curtain wall  
at a midwestern research center  
keeps maintenance costs to a minimum.*

*ARCHITECTS AND ENGINEERS:  
Larsen and Ludwig.*



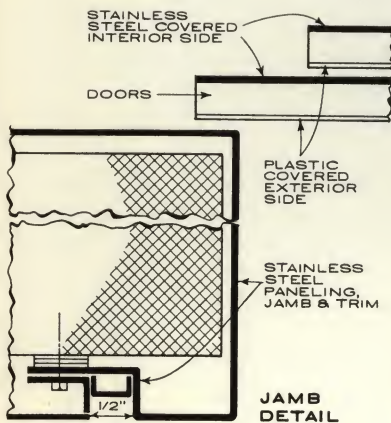
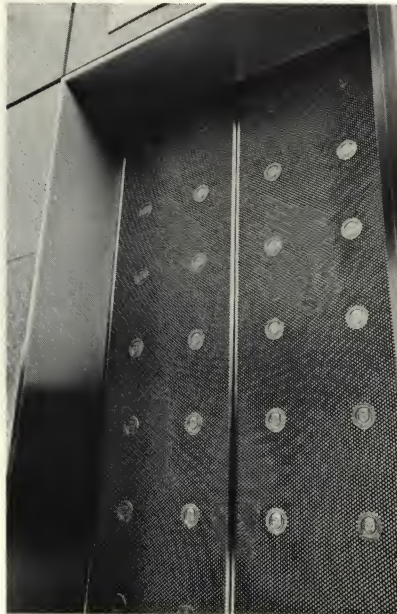


# ELEVATORS AND ESCALATORS



*Stainless steel, interwoven with bronze, provides a striking pattern on elevator doors at Toronto-Dominion Bank Building, Montreal.*

**ARCHITECTS:**  
*Ross, Fish, Duschenes & Barrett.*



*White elevator doors offer sharp, attractive contrast to stainless wall in the Union Carbide Building, New York. Details are shown above.*

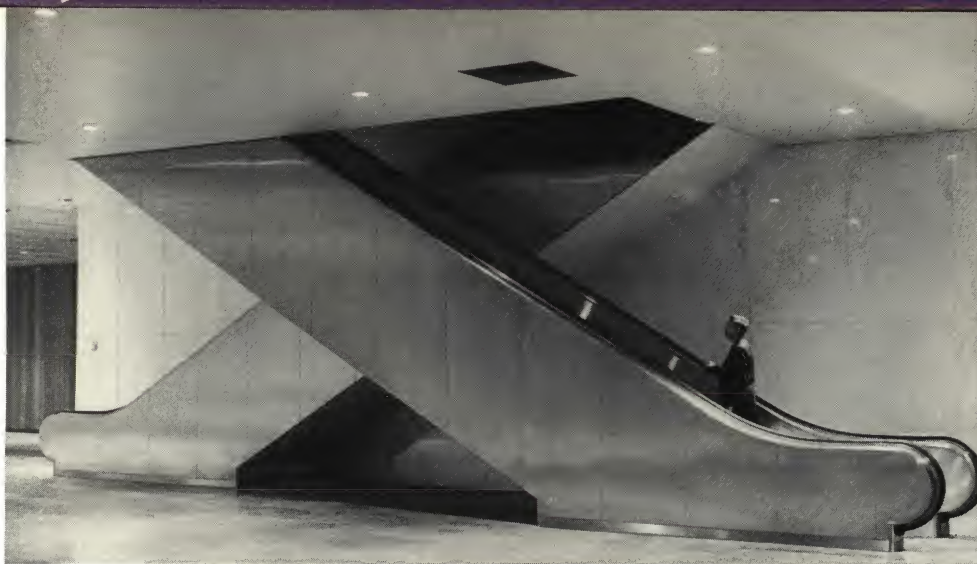
**ARCHITECTS:**  
*Skidmore, Owings and Merrill.*



*Stainless steel doors and ceiling-high wall panels complement white marble wall surfaces at elevator banks in the J. C. Penney Building, New York.*

**ARCHITECTS:**  
*Shreve, Lamb & Harmon Associates.*





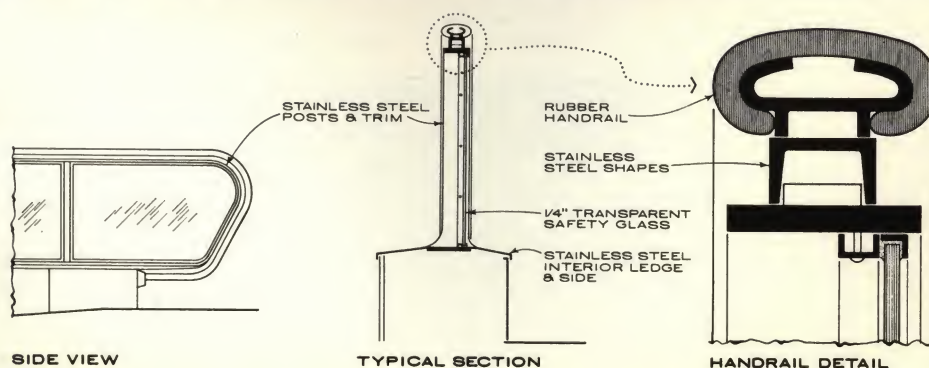
*Stainless steel closed-balustrade escalators serve all public floors of Smithsonian Institution's Museum of History and Technology in Washington, D.C., contrasting vividly with marble walls.*

**ARCHITECTS:**  
McKim, Mead & White;  
Steinmann, Cain & White.



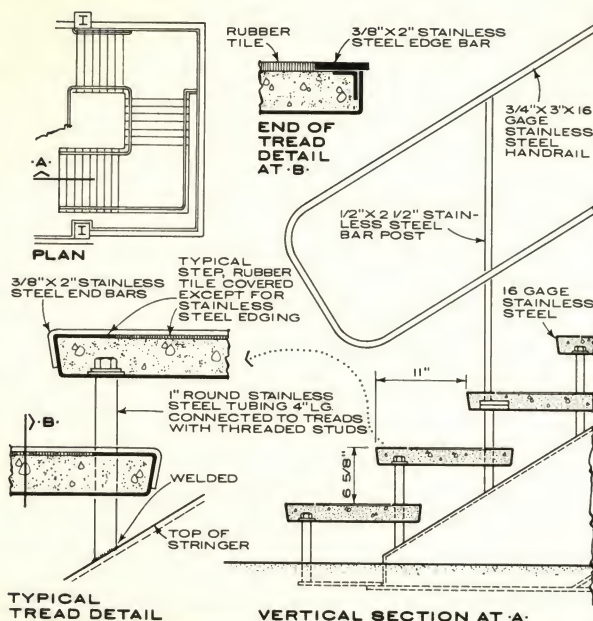
*Open-balustrade escalators in the Toronto store of Robert Simpson Co., Ltd., have balusters of mirror-finish stainless. Details are shown below.*

**ARCHITECT:**  
Maxwell Miller.



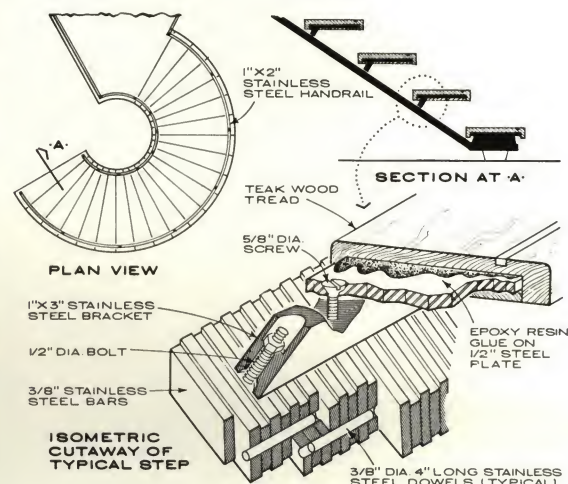


# STAIRS AND HANDRAILS



Rectangular stainless steel tubing is used for straight-run staircase in the United Engineering Center, New York. Details are shown at right.

ARCHITECTS:  
Shreve, Lamb  
& Harmon Associates.



An assembly of 128 stainless steel bars, each with a different curvature, supports the dramatic, free-standing helicoidal staircase in the Canadian Imperial Bank of Commerce, Montreal. Details are shown at right, above.

ARCHITECTS:  
Clifford and Lawrie.





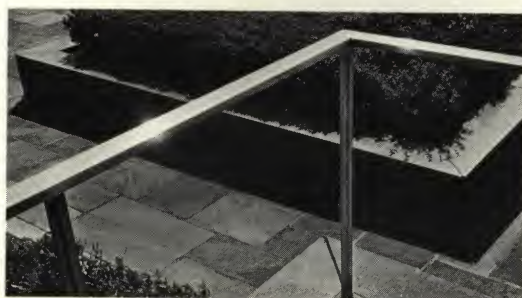


*Stainless steel wire is used imaginatively in airy, suspended staircase in the Kansas Power and Light Company Building, Topeka.*

**ARCHITECTS:**  
Albert C. Martin and Associates.

*Durable, corrosion-resistant stainless handrails and balusters at Stevens Institute of Technology, Hoboken, New Jersey, provide beauty and resistance to corrosive urban atmosphere.*

**ARCHITECT:**  
John J. McNamara.





# DRAMATIC APPLICATIONS





*Aesthetically pleasing use of stainless steel for sheathing of functional structures is illustrated by the water intake gate structures at the Niagara Power Project, Niagara Falls, New York.*

*ARCHITECTURAL CONSULTANT: John B. Peterkin.*

*ENGINEERS AND DESIGNERS: Uhl, Hall and Rich.*

*The awesome, 630-foot-high stainless steel Jefferson National Expansion Memorial, commonly known as the St. Louis Gateway Arch, is a towering tribute to its designer, the late Eero Saarinen.*

*ARCHITECTS: Eero Saarinen and Associates.*





# SCULPTURE

*"Vapor Trails," a sculpture affixed to the face of Aviation High School, Long Island City, New York, symbolizes jet planes climbing to the threshold of outer space. Stainless sheets and tubes create the effect.*

**SCULPTRESS:**  
Gwen Lux.



*Life-sized sculpture of Father Pierre Marquette, pioneer Jesuit, fabricated of fully annealed stainless, is at John Carroll University, Cleveland.*

**SCULPTORS:**  
Mary and Marik Masson.

*Natural gas stainless steel torches flame brightly at the Canadian pavilion at Expo 67.*

**DESIGNER:**  
Julian Hebert.







*"Infinity," a stainless steel orrery—man's visual conception of his universe—graces the south entrance of the Smithsonian Institution's Museum of History and Technology, Washington, D.C.*

**COLLABORATING SCULPTORS:**  
*Jose de Rivera and Roy Gussow.*



*"Man," the 46-ton theme sculpture of Expo 67, was executed in stainless.*

**SCULPTOR:**  
*Alexander Calder.*



# STANDARDS AND SIGNS

*Canadian Imperial Bank of Commerce Building*



*Municipal Services Building*



*The tallest stainless steel flagpoles in North America are the graceful 110-foot standards in front of the Municipal Services Building, Philadelphia. Canada's tallest—90 feet—front the Canadian Imperial Bank of Commerce Building, Montreal.*

*Twin, 60-foot stainless steel flagpoles also front Union Carbide Corporation's New York headquarters.*





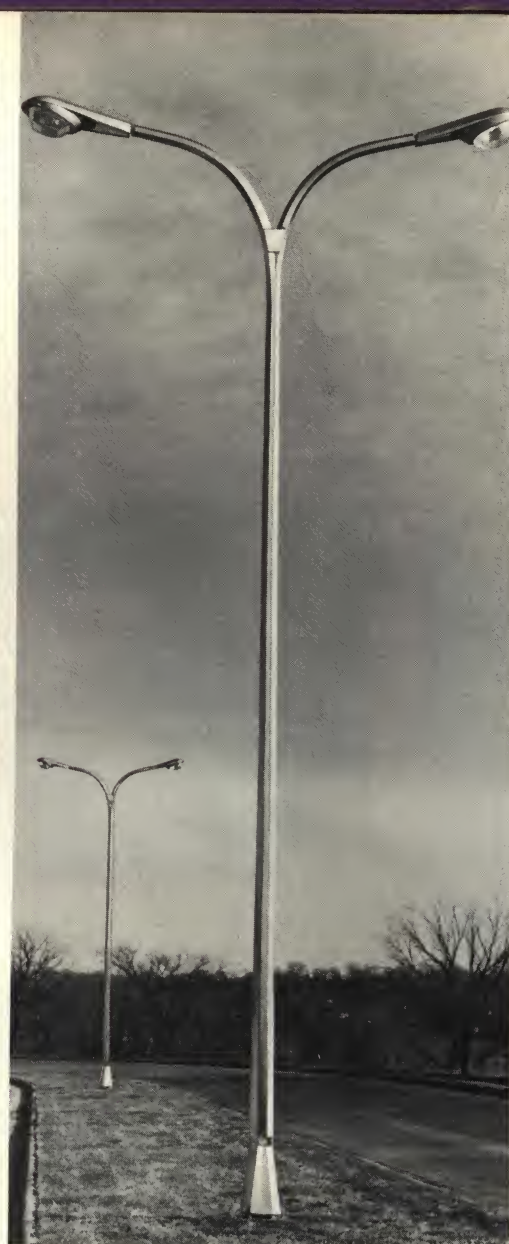
Special



Residential

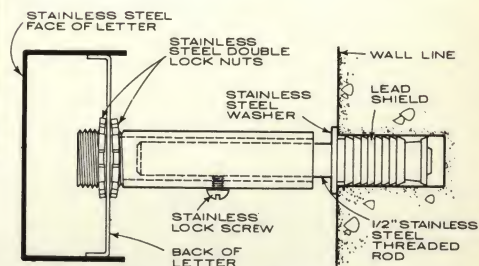


Municipal



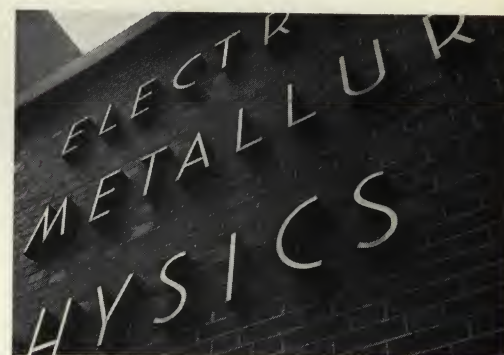
Highway

*Design versatility of stainless steel is apparent when one considers the broad range of lighting standard applications—highway (State of Minnesota); municipal (Philadelphia); residential; and special (Expo 67).*



TYPICAL LETTER ANCHORING DETAIL

*Whether free-standing or affixed to the structure, the stainless identification sign is informative, decorative and durable.*

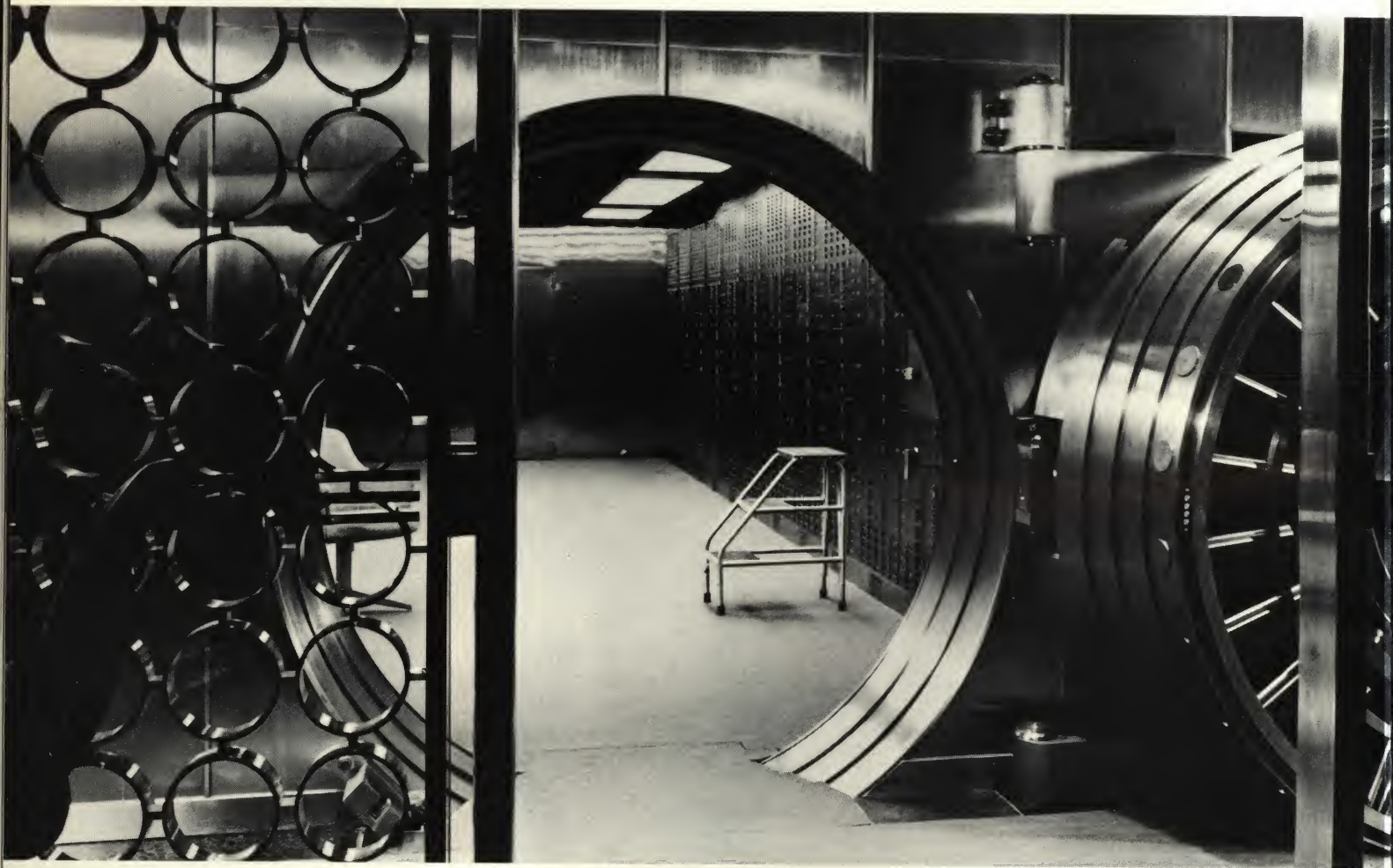




# INTERIOR FURNISHINGS

*Stainless chandelier enhances stairwell  
at Stevens Institute of  
Technology, Hoboken, New Jersey.*

*ARCHITECT:  
John J. McNamara.*



*Both vaults and grilles at the Wells Fargo Bank, San Francisco, are stainless steel.  
ARCHITECTS: Ashley, Keyser and Runge.*



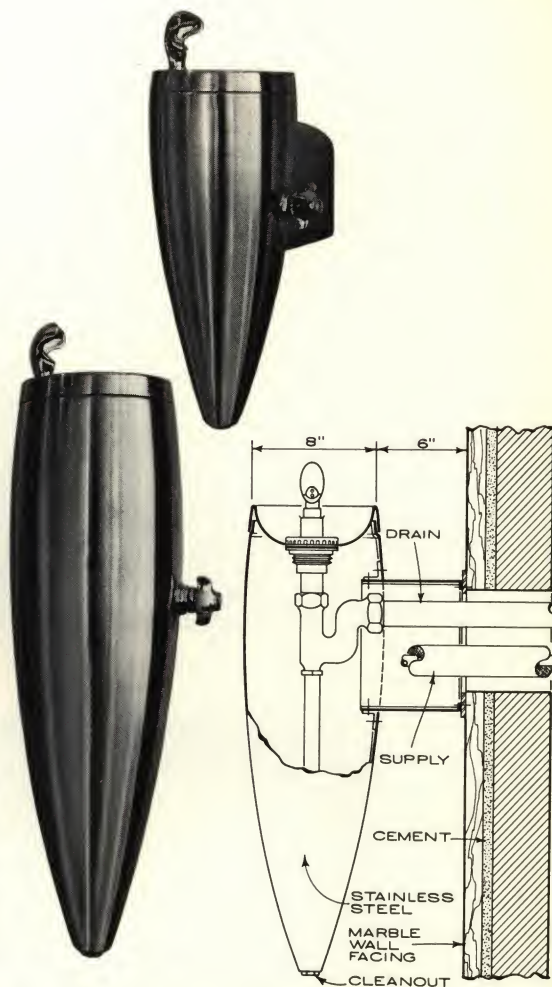
*Modern flat-dish fountains in stainless steel are sanitary and easy to maintain.*

**ARCHITECT:**  
*James S. Sudler.*



*Deep-dish stainless fountains are used at Smithsonian Institution's Museum of History and Technology. Details are shown at right.*

**ARCHITECTS:**  
*McKim, Mead & White; Steinmann, Cain & White.*



*Planter and directory in the Mobil Building, New York, are stainless.*

**ASSOCIATED ARCHITECTS:**  
*John B. Peterkin and Harrison & Abramovitz.*

*Stainless service unit, incorporating intercom, fire hose and extinguisher, is designed into attractive interior of award-winning Montreal Trust Company's Toronto branch building.*

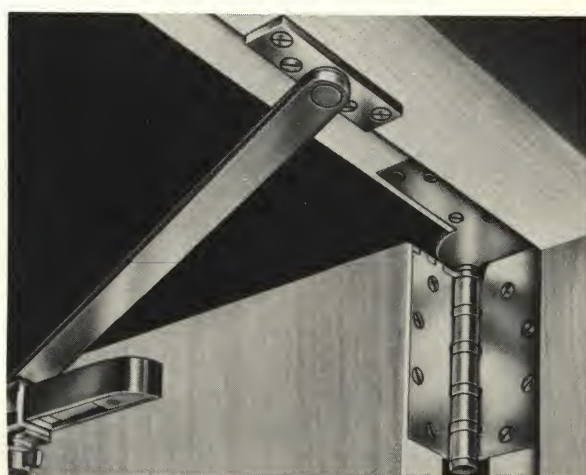
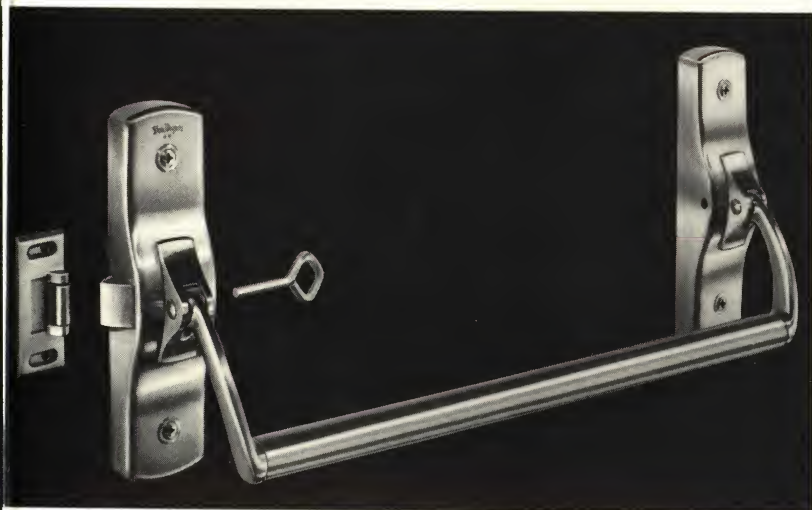
**ARCHITECTS:** *Page and Steele.*



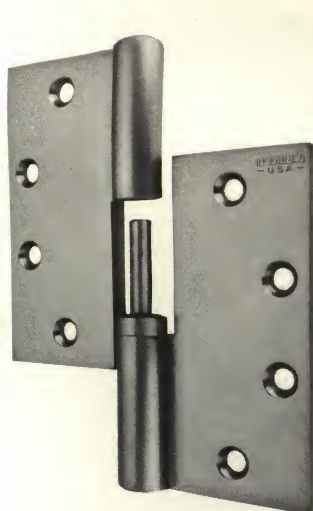
# FINISH HARDWARE







*Door pulls, knobs, push plates, hinges, kickplates and other finish hardware of stainless steel provide sturdy service with minimal maintenance.*

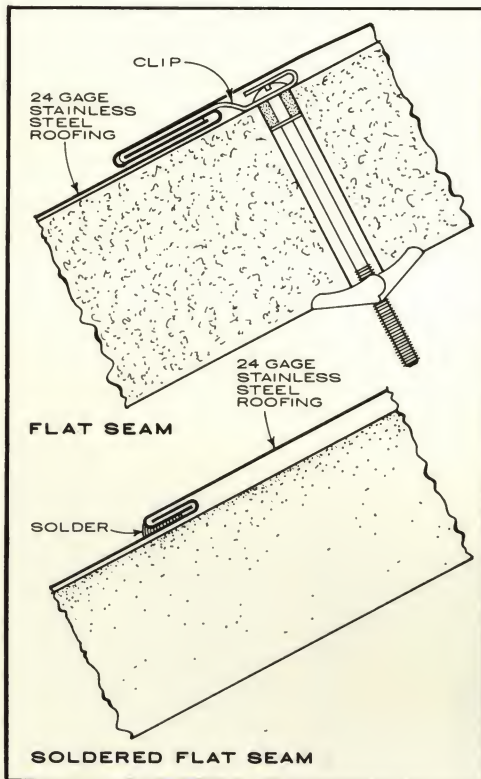




# ROOFING

*The batten seam stainless steel roof of St. Joseph's Church, Sharon, Pennsylvania, combines attractive appearance with corrosion resistance.*

**ARCHITECTS:**  
*Stickle and Associates.*



*The parabolic roof of the main concourse of the International Arrivals Building at John F. Kennedy International Airport, New York, is sheathed with 26,000 square feet of stainless steel.*

**ARCHITECTS:**  
*Skidmore, Owings and Merrill.*

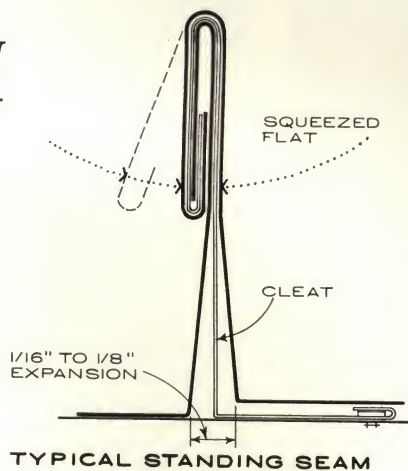






*Stainless is used for residential roof and gutter on this attractive Pennsylvania residence.*

**ARCHITECT:**  
*John Peckruhn.*



*Standing seam stainless steel roofing was used on the Heppenstall Building, Pittsburgh.*

**ARCHITECTS:**  
*Hoffman & Crumpton.*



# WATERPROOFING AND DRAINAGE

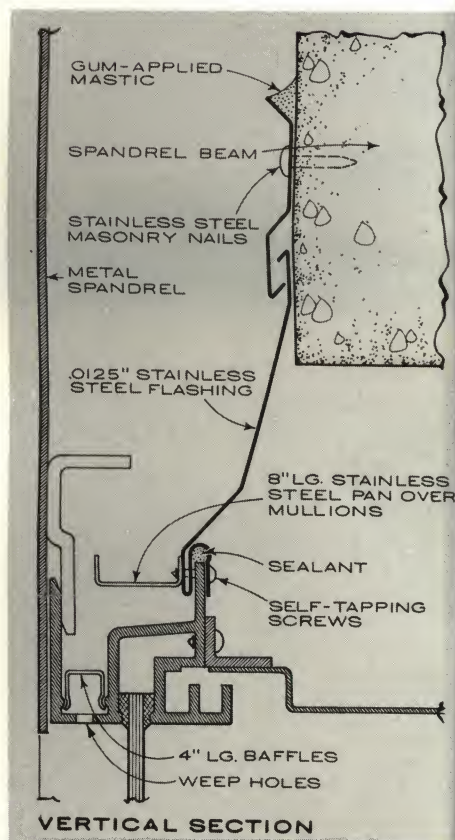
*Stainless steel gutters, downspouts and flashing are used on the Trinity Evangelical Lutheran Church, Latrobe, Pennsylvania.*

**ARCHITECTS:**  
*Mansell-McGettigan-Fugate.*



*Stainless steel spandrel flashing provides trouble-free protection against penetration of moisture at Federal Office Building, New York.*

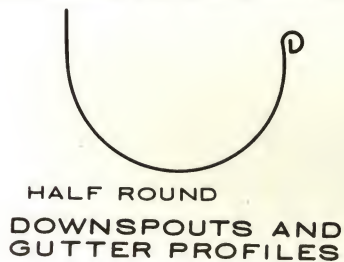
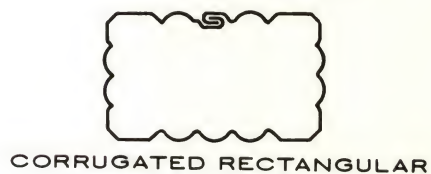
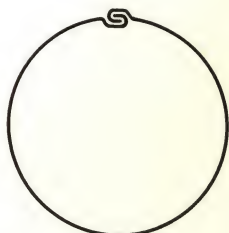
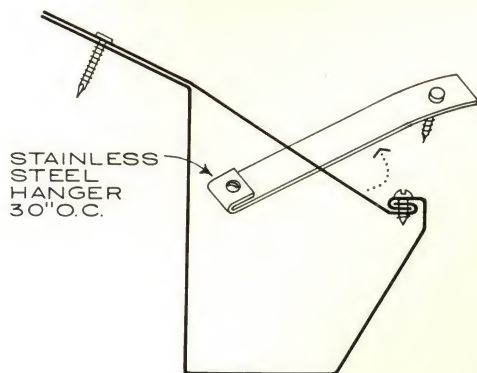
**ARCHITECTS:**  
*Jacobs, Poor and Eggers (a joint venture of: Kahn and Jacobs; the office of Alfred Easton Poor; and Eggers and Higgins).*



*Detail of spandrel flashing at Chase Manhattan Bank Building, New York.*

**ARCHITECTS:**  
*Skidmore, Owings and Merrill.*

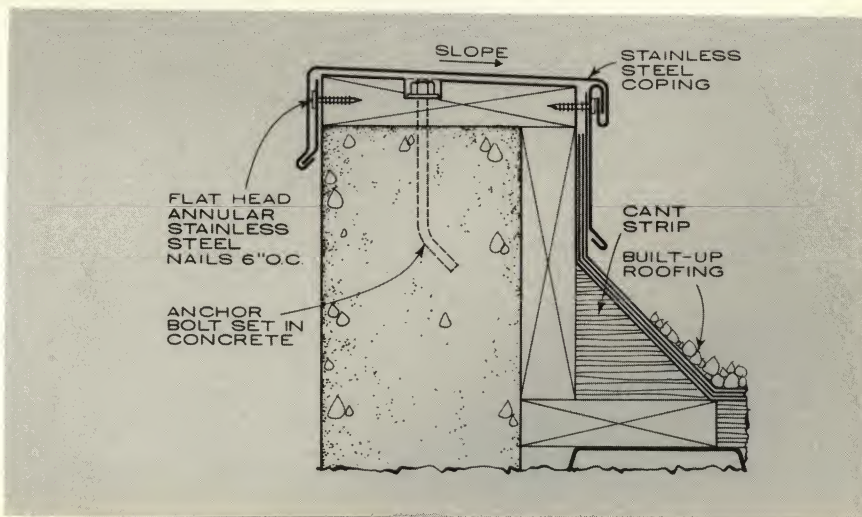




*Stainless steel parapet flashing at University of Miami (Ohio) prevents water penetration below the masonry copings.*

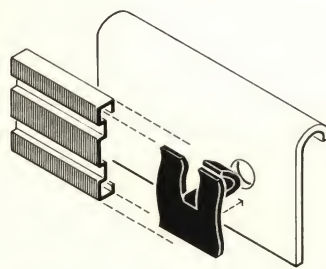
ARCHITECTS:  
Harry Hake & Harry Hake, Jr.

*Stainless steel coping on masonry wall performs waterproofing function of both flashing and coping.*

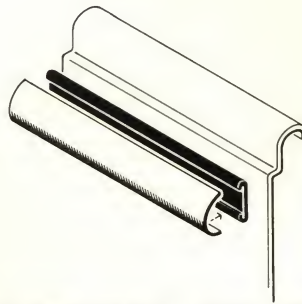




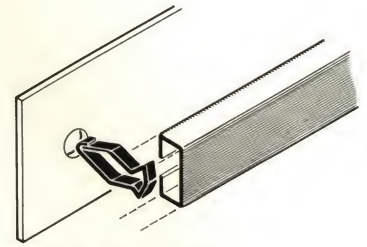
# FASTENERS AND ANCHORS



**SNAP-ON CHANNEL  
RETAINER**



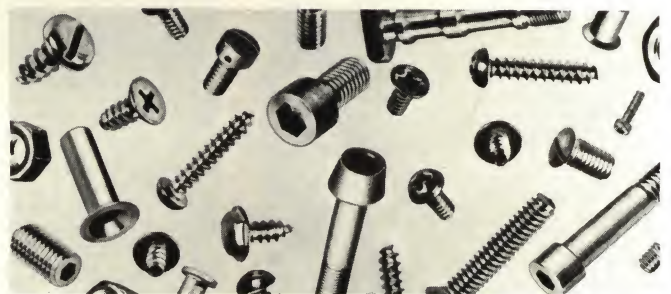
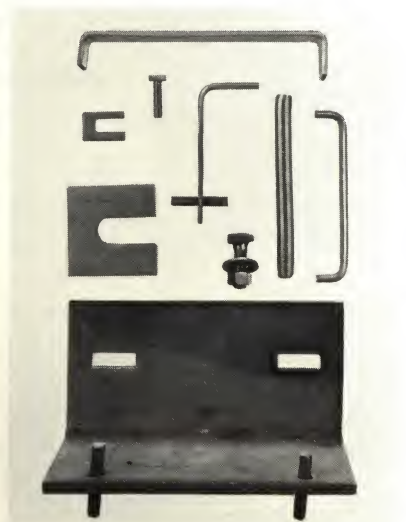
**SNAP-ON OVAL RETAINER**



**SNAP-ON CLIP**

*Stainless snap-on fasteners facilitate attachment of components.*

*Corrosion resistance of stainless steel makes it particularly appropriate for masonry anchors. Stainless will not corrode and cause streaks or stains.*



*Stainless steel fasteners provide needed strength and will not cause streaking, corrosion spots or other surface blemishes, which can occur with other metals.*



## B. THE STORY OF STAINLESS

Up to this point, information has related to various common uses of stainless steel in architecture. A number of representative applications have been illustrated, ranging from purely aesthetic to strictly functional, to demonstrate the broad versatility of the metal.

Whatever the application, however, good design requires more than merely an understanding of aesthetic principles and functional requirements. The competent designer also must understand the nature and characteristics of materials and how they can be used most efficiently. A knowledge of how the material is made will improve this understanding.







*Typical capacity of an electric furnace is from 50 to 100 tons.  
The charge includes steel scrap and alloying materials.*



# HOW STAINLESS STEEL IS MADE

## First of all, what is stainless steel?

In general terms, it may be defined as a family of corrosion-and-heat-resisting iron-based alloy steels containing a minimum of approximately 11% chromium. Its corrosion resistance may be improved by increasing the chromium content; and modification with nickel improves cold workability, as well as corrosion resistance. Among other alloying elements added for certain applications are molybdenum, manganese, columbium, aluminum, sulfur and titanium.

The making of stainless steel involves a series of processes similar to those used in making other kinds of steel. Because most architectural uses of stainless steel require that the metal be in the form of sheet or strip, a brief explanation of how these are produced will serve appropriately to illustrate the principal steps in the manufacturing process.

## Melting

Because stainless steels require precise control of their chemical composition they usually are produced in an electric furnace. Special high-quality grades are also melted in vacuum

furnaces and by a vacuum consumable electrode process. Recently, in an effort to reduce melting time and thereby cost, stainless has been produced in a basic oxygen furnace.

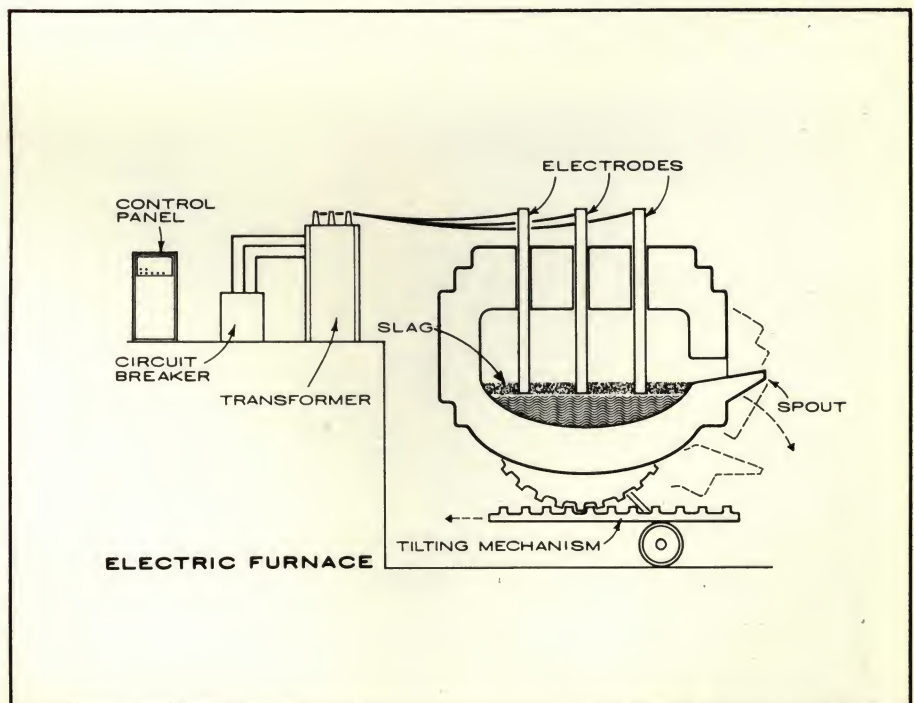
Essentially, the electric furnace is a huge cylindrical steel pot, lined with refractory brick and fitted with a cover. Large carbon electrodes extend down through the cover to within a few inches of the "charge," and electric arcs, struck between these electrodes and the metal, provide the intense heat required for melting.

The charge consists of steel scrap, and carefully proportioned amounts of alloy additions. The resulting "heat," which weighs from 10 to 100 tons, is completed in from 8 to 12 hours. Then the furnace is tilted, as seen in the photo at left, and the molten metal is poured into a ladle.

## Casting

Molten steel is then cast into solid form. The most common practice is to form ingots by casting the metal into iron molds. Ingots formed in this manner may have a cross section as large as 32 by 60 inches and be as long as seven feet.

In an effort to reduce the cost of







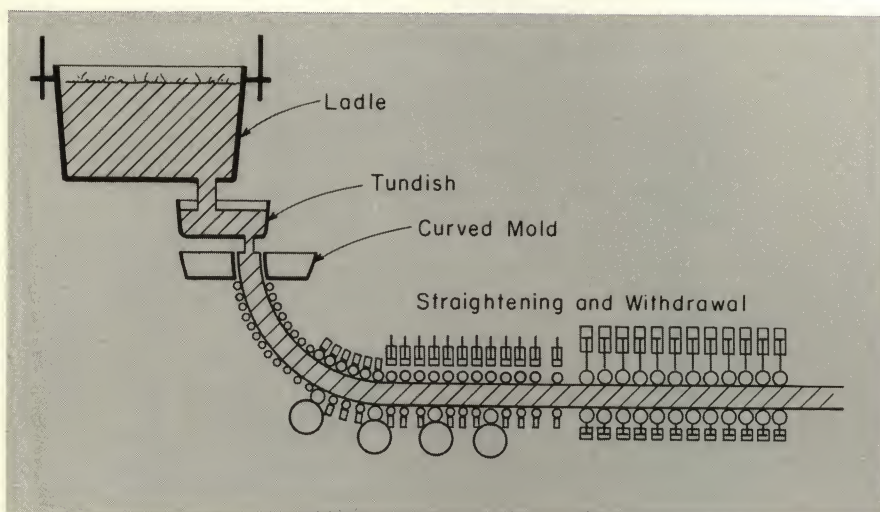
*Molten steel is cast into molds to form rectangular blocks of steel called ingots.*

steel, several new methods have recently been developed. It appears that two of these methods will, in the future, largely replace the ingot form.

One of these methods is continuous casting. In this process a continuous slab is formed by slowly flowing the metal through a water-cooled vibrating mold. The slab is then passed through a cooling water spray and cut into slab lengths.

Another recently developed method is pressure pouring. In this process, the metal is poured into a pressure vessel positioned beneath a slab-shaped mold. The vessel and the mold are connected by a tube. By introducing pressurized air at the bottom, the steel flows up through the tube and into the mold.

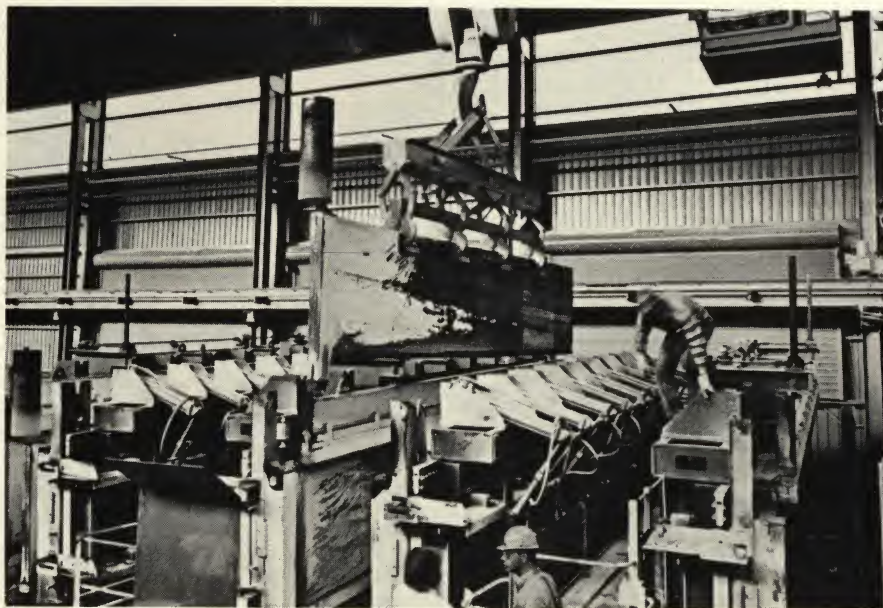
The advantage of continuous casting and pressure pouring is that they both eliminate the soaking and slabbing mill processes, because the metal is cast directly into a slab form.



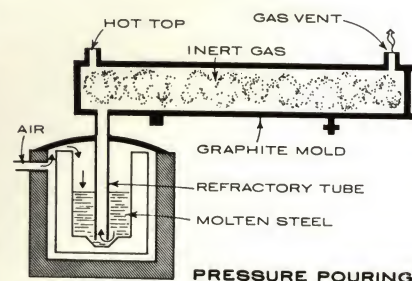
*In continuous casting, molten stainless is poured into the top of a mold and exits as an uninterrupted length of solid metal from the bottom.*

### Slabbing

If the steel is cast into ingots, it must be allowed to cool until it can be handled without the mold. When the mold is "stripped," the ingots are placed in "soaking pits." Here the metal is brought to the temperature required for rolling and "soaked" until this temperature is uniform throughout the ingot. At the "slabbing mill" the



*Molten steel is pressure-poured into a mold to produce slabs of stainless.*





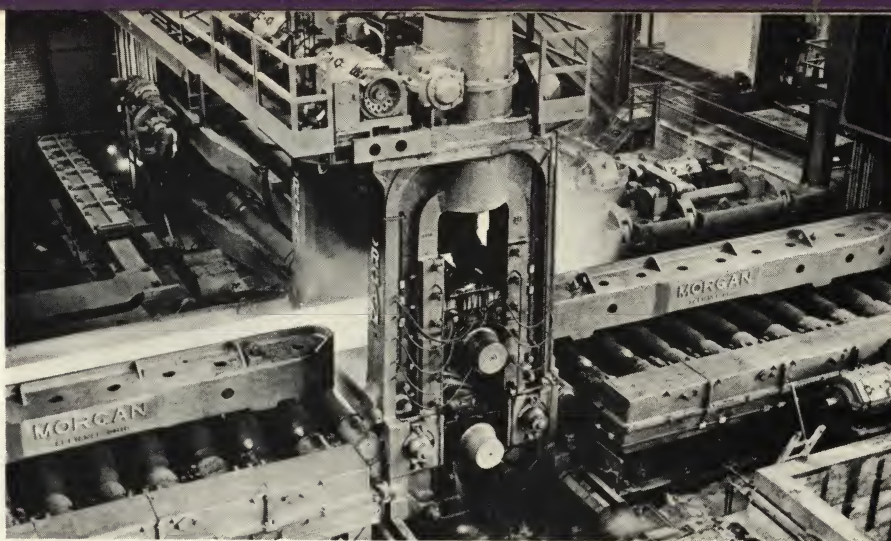
ingots are rolled and cropped to a size suitable to the processing that they are to follow. A typical slab might be six inches thick, 36 inches wide and about 15 feet long.

No matter how it is produced, a stainless slab is "conditioned," usually by grinding, to remove imperfections which might be rolled into the surface during hot rolling. This is one more step towards insuring a high-quality finish.

### Hot Rolling

After again being reheated to approximately 2300° F., the slab is passed repeatedly between a series of massive rolls which reduce it to a long ribbon of stainless steel less than a quarter of an inch thick, two to four feet wide, and hundreds of feet in length. After cooling, the metal has a dull, reddish-gray color, much like any other steel, and is referred to as "hot strip."

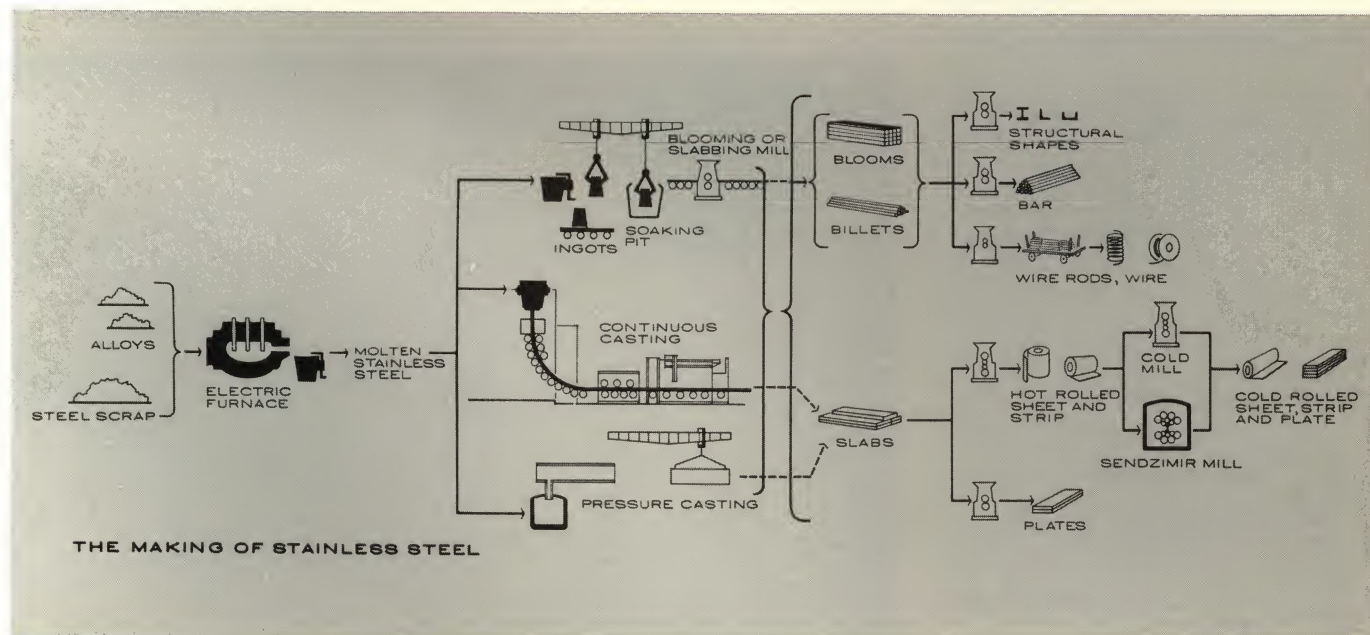
The metal then is "annealed" (heated and cooled under controlled conditions to relieve internal stresses and soften the metal), and "descaled" by passing it through an acid bath to remove surface scale developed in the hot rolling and high-temperature annealing processes. Now light gray in color, and having a "hot rolled finish," it is coiled for transfer to the cold rolling mills.



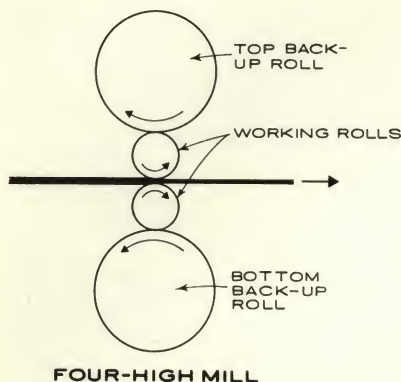
*Stainless ingots are rolled into slabs by feeding the metal through reversing rolls; first in one direction, then the other.*



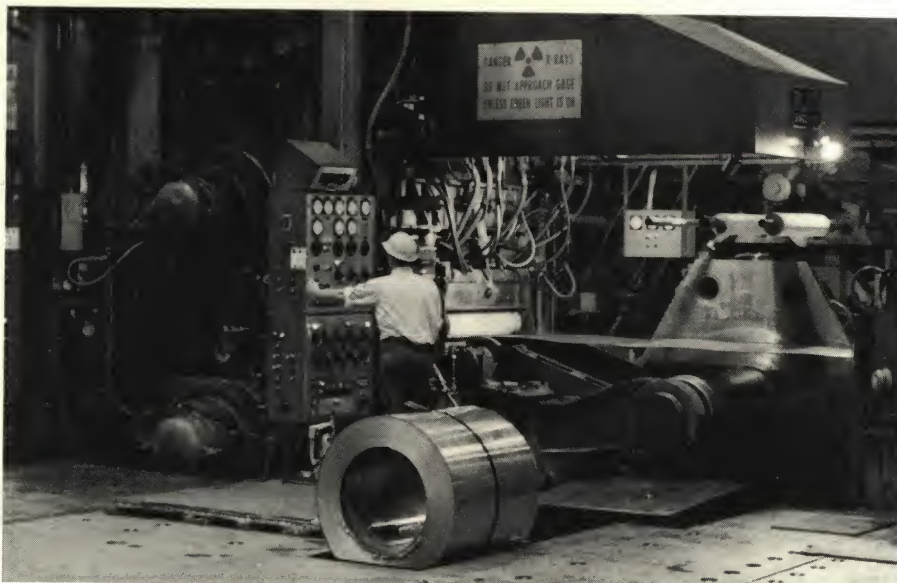
*After slabbing, stainless is reheated and passed between rolls to reduce its thickness. This hot rolling process produces hot rolled strip, hundreds of feet in length.*







*To produce various sheet and strip lengths, stainless is passed through a shearing line.*



### Cold Rolling

Further reduction in thickness is accomplished by cold rolling, during which the metal takes on its characteristic metallic sheen.

Cold rolling commonly is performed on a "four-high reversing mill." This is a rolling mill with two small-diameter working rolls, each supported by full-length contact with a much larger backup roll to prevent bowing under the great pressures required. The coil is fed through, first in one direction, then in the reverse. Each pass reduces its thickness.

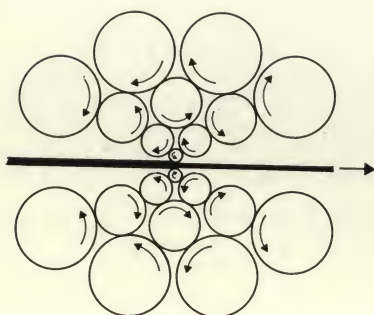
Another type of rolling mill, used by some producers, is the Sendzimir Mill. This has a "cluster" of 20 rolls of four different diameters, the working rolls being very small in diameter. These

mills are capable of very high reduction with maximum dimensional control, resulting in a minimum variation of sheet thickness from edge to edge.

Cold rolling accomplishes more than simply a dimensional change. It is, in fact, a refinement. Besides improving surface smoothness it also alters the grain structure and mechanical properties of the metal.

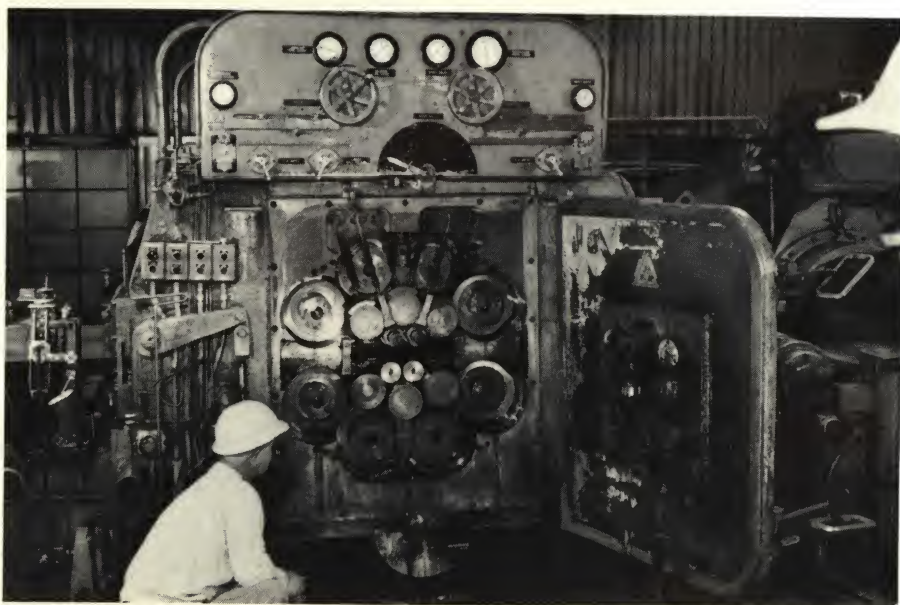
### Final Annealing, Descaling and Temper Rolling

Before shipment, the coil is given a final anneal and descale to give the desired mechanical properties and provide an attractive surface. Then it usually is passed through highly polished rolls which "set the shape" and

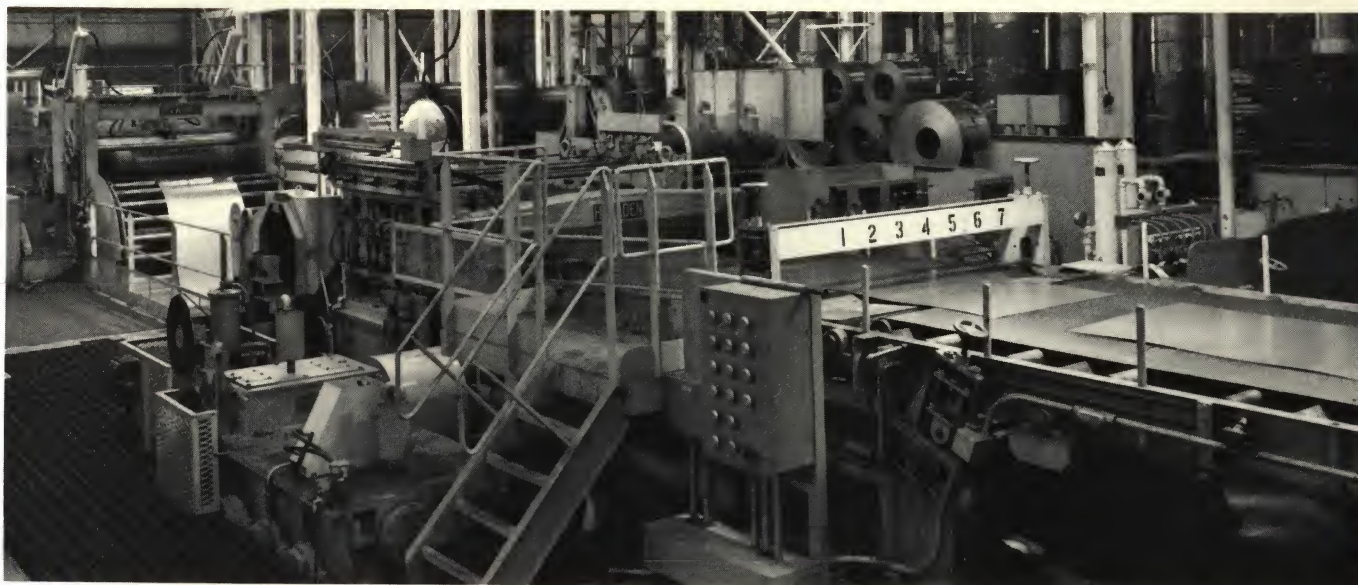


**SENDZIMIR MILL**

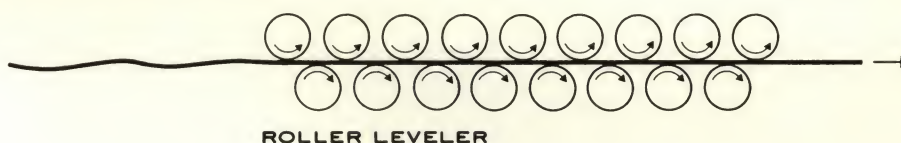
*In a Sendzimir Mill, maximum reduction in thickness is achieved with minimal deviation from edge to edge. The mill illustrated is open to show its cluster of 20 rolls.*







*In the roller leveling process, stock is uncoiled (left), fed through a series of small rollers, then sheared to desired lengths (right).*



brighten the surface. The latter process is called a "skin pass."

The large coils, weighing from several hundred pounds to several tons, may be shipped as is, in the form of coiled sheet or strip stock with a mill-rolled finish, or processed still further in the mill before shipment.

The material may be:

- Cut to lengths, for shipment as cut strip or sheets, with either rolled or polished finishes;
- Mill polished in the coil, for shipment as coiled polished sheet or strip; or

- Cut to narrower widths by "slitting," for shipment as coiled strip.

#### **Roller Leveling and Cutting to Length**

Much of the stainless used in architectural work is supplied by the mill in the form of cut sheet of various standard sizes, but special sizes may be ordered from the producing mill. To produce these sheets, the stock is uncoiled, fed between a series of small rollers to "level" it, then through a "shear line," where it is cut to desired lengths.

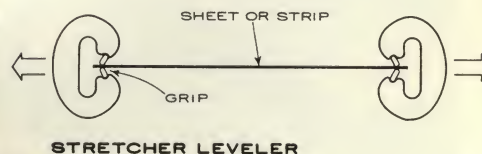
#### **Stretcher Leveling**

For many applications, cut sheet stock requires better flatness than can be obtained by roller leveling. This is achieved by a process known as "stretcher leveling."

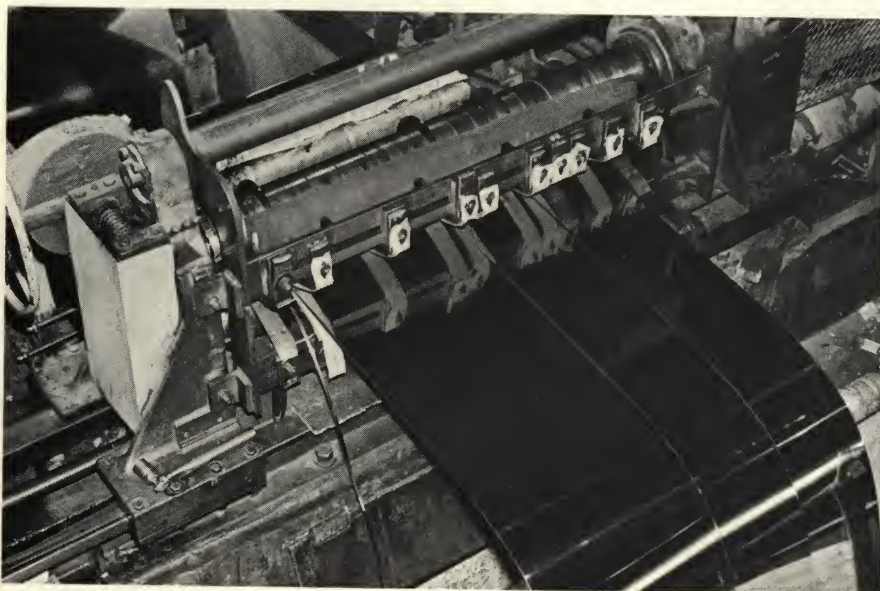
As the name indicates, this is a mechanical process of stretching the cut sheets to stress them just beyond the yield point, so that they become flat. The sheets are gripped securely at their ends and stretched lengthwise. Then, ends and edges are trimmed accurately to dimension and squareness.



*When cut stock requires a greater degree of flatness than obtainable by roller leveling, the sheets are gripped at their ends and stretched lengthwise in a process called stretcher leveling.*



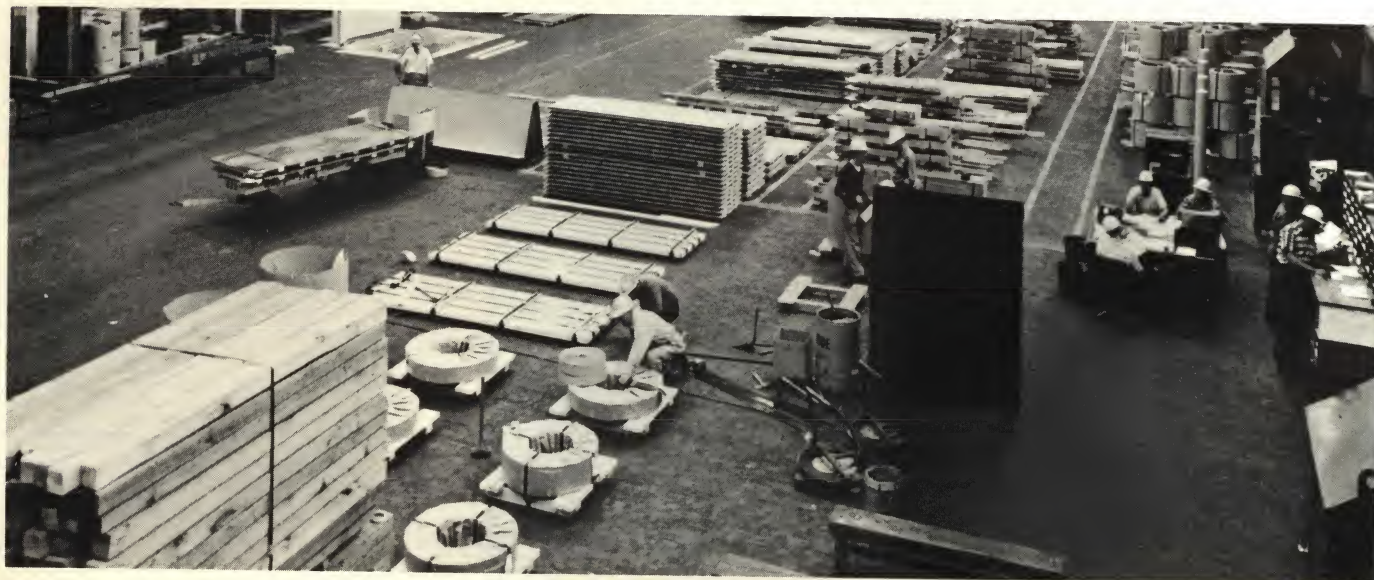




To cut to narrow widths, stainless is passed through slitters, which are essentially adjustable rotary shears.



Coil, sheet and strip stock is inspected and interleaved with paper to protect the finish, is packaged, and readied for shipment (below).



## Polishing

Several standard polished finishes may be applied in the mill to sheet or strip stock. Coil stock is polished by passing it slowly over a polishing table where overhead abrasive belts are brought carefully into contact with its surface. Cut sheets and strip also are polished on a polishing table, using overhead abrasive belts of varying degrees of fineness.

*More information about polishing and other finishing methods is provided in a later section.*

## Slitting

The cutting of coiled sheet stock into narrower widths is accomplished by slitting knives, as shown at the left. A slitter is a set of rotary shears which may be adjusted to produce any width of strip desired. After slitting, the stock may be either re-coiled for shipment or cut to specified lengths and shipped in that form.

## Packing for Shipment

The finished product is inspected carefully and packed for shipment to the customer. To protect the finish, coil stock usually is interleaved with paper. Cut sheet and strip are protected in a similar manner, and frequently are packed in strong wooden crates. When more positive protection of polished surfaces is specified by the customer, they are covered with a temporary adhesive film of paper, plastic or other material. This often remains in place as a protective coating during subsequent fabricating operations, reshipment, and installation on the building. At that time it should be promptly removed.



# TYPES AND PROPERTIES

## Classifications and Types

As previously mentioned, there are many different types of stainless steel. American Iron and Steel Institute lists 38 standard types. In addition, many special, proprietary types are produced.

In all varieties of stainless steel, chromium is the element which gives the metal its corrosion resistance. Chromium also contributes to the high strength and hardness. Nickel is an important alloying element; its addition in quantities of 4% or more improves corrosion resistance, ductility, and fabricating characteristics. Manganese is also important. It is included in small amounts in all types, and in quantities of 6% or more in some. Its effect is similar to that of nickel and, in some types of stainless steel, it is used to replace part of the nickel. Molybdenum, silicon, and other elements may be used in small amounts to give special properties.

The stainless steels are divided into three groups according to metallurgical structure: austenitic, martensitic, and ferritic. While this classification is of interest chiefly to metallurgists, architects should recognize the basic differences involved. *Austenitic* stainless steels (AISI 200 and 300 series) contain nickel and are essentially nonmagnetic. They cannot be hardened by heat treatment, but can be hardened very ef-

fectively by cold working. They are ductile and can be fabricated and welded readily.

*Martensitic* stainless steels (AISI 400 series) contain little or no nickel and are magnetic. They can be hardened by heat treatment but cannot be hardened readily by cold working.

*Ferritic* stainless steels (also AISI 400 series) contain no nickel and are magnetic. They are not hardenable by heat treatment, and only slightly hardenable by cold working. They can be fabricated readily, but are less ductile than the austenitic grades.

## Architectural Types

Of the 38 standard types of stainless steel, six are of primary importance to the architect. They are AISI Types 201, 301, 302, 304, 316, and 430. Types 305 and 410 are also used—primarily for bolts, nuts, screws and other fasteners.

*Type 302* has been used widely in architectural work. This austenitic alloy, containing 18% chromium and 8% nickel (often known as "18-8"), has been used on building exteriors since the late 1920's and is well-known by architects. There are good reasons for its wide use in architectural work; it is highly resistant to atmospheric corrosion, very strong and hard, readily available in all commercial forms, and fabricated easily by all standard techniques.

*Type 304*, a low-carbon variation of Type 302 having generally similar properties but improved weldability, now largely has replaced Type 302 in architectural applications. It often is used where Type 302 formerly was specified and is the type most readily available in many forms. Because the two types are essentially similar, the designation "*Type 302/304*" commonly is used to indicate that either is acceptable.

*Type 301* is a modification of Type 302, having slightly less chromium and nickel. This reduction is not enough to impair its corrosion resistance or ductility, but it does increase its work-hardenability. Type 301 can be cold rolled to very high tensile strengths (over 200,000 psi) and still retain some workability.

*Type 316* contains more nickel than Type 302/304, as well as 2% to 3% molybdenum, added to improve corrosion resistance. In locations exposed to a severe marine environment or to extremely corrosive industrial atmospheres, Type 316 should be considered.

*Type 201* is a more recently developed austenitic alloy containing chromium, nickel and manganese. It is similar in most of its properties to Type 301/302 but is stronger, harder, and does involve more springback during fabrication.

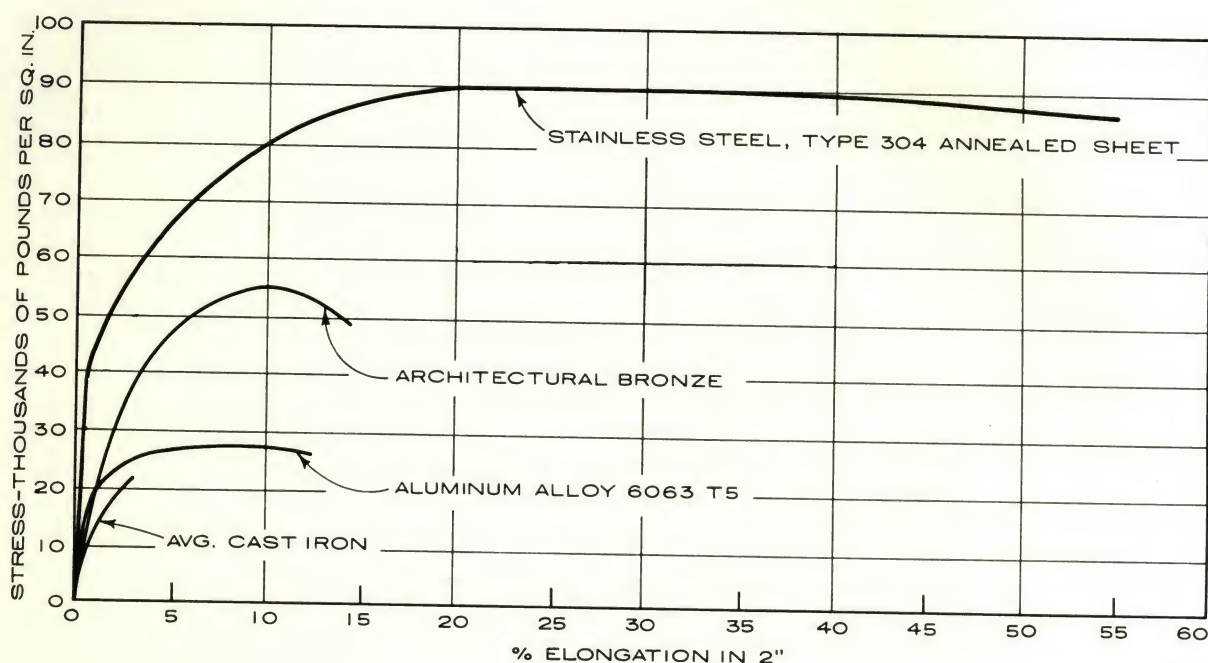
*Type 430* is a ferritic chromium alloy which is somewhat less resistant to

## PROPERTIES OF THE ARCHITECTURAL STAINLESS STEELS

AISI Type No.	201	301	302	304	316	430
Composition, per cent						
Chromium	16-18	16-18	17-19	18-20	16-18	14-18
Nickel	3.5-5.5	6-8	8-10	8-12	10-14	—
Manganese	5.5-7.5	2 max.	2 max.	2 max.	2 max.	1 max.
Molybdenum	—	—	—	—	2-3	—
Carbon (max.)	.15	.15	.15	.08	.08	.12
Representative mechanical properties (sheet & strip; annealed)						
Tensile strength, 1,000 psi	115	110	90	84	84	75
Yield strength, 0.2% offset, 1,000 psi	55	40	40	42	42	50
Elongation in 2 in., per cent	55	60	50	55	50	25
Modulus of elasticity, psi x 10 <sup>6</sup>	28.6	28.0	28.0	28.0	28.0	29.0
Hardness, Rockwell B	90	85	85	80	79	85
Physical properties						
Weight, lb/cu in.	0.28	0.29	0.29	0.29	0.29	0.28
Thermal conductivity (at 212° F) btu/sq ft/hr/deg F/ft	9.4	9.4	9.4	9.4	9.4	15.1
Coefficient of thermal expansion in/in/deg F x 10 <sup>-6</sup> (32° F to 212° F)	9.7	9.4	9.6	9.6	8.9	5.8



## STRESS-STRAIN CURVES FOR ARCHITECTURAL METALS



corrosion than the austenitic 200 and 300 series.

The properties of the major architectural types of stainless steel are given in the table on page 35.

### Strength

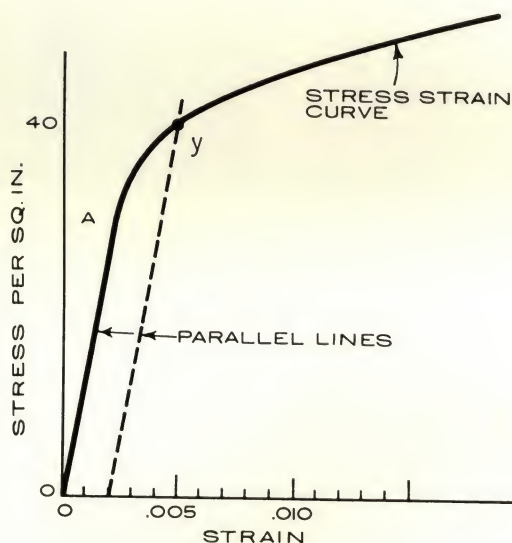
Stainless is by far the strongest of the architectural metals, as shown on the stress-strain curves (above). Note that the curve for stainless steel continues beyond the breaking point of other metals, emphasizing its superior ductility.

Architectural metals do not exhibit a distinct yield point; their stress-strain curves show a gradual transition from a straight line to a curve. Yield strength therefore must be established arbitrarily, and it has become customary to consider the yield strength of stainless steel as that point at which the stress-strain curve intersects the "0.2% offset" line, as shown in the diagram (right).

### Hardness

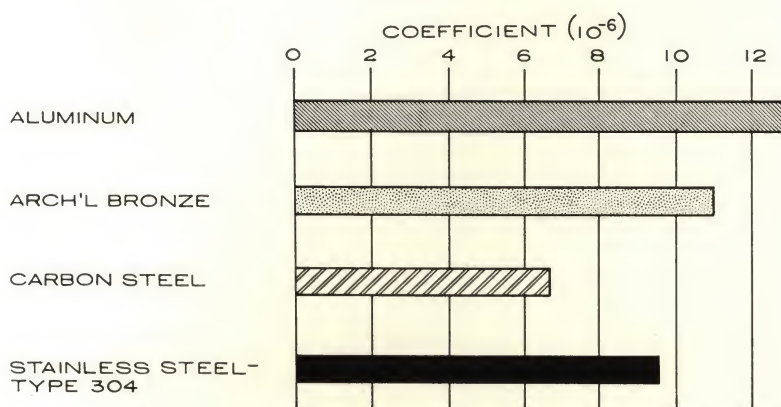
The austenitic stainless steels have the property of being hardenable by cold working. This usually is accomplished in steel mills by cold rolling, which not only hardens the metal but also increases yield strength and tensile strength.

### YIELD STRENGTH — DETERMINED BY OFFSET





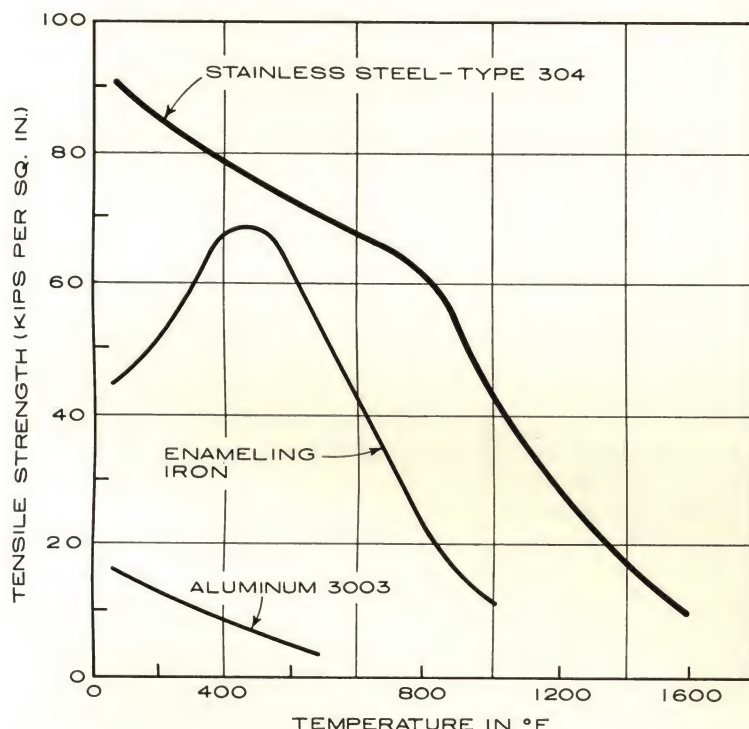
## COEFFICIENTS OF THERMAL EXPANSION



In addition to the annealed condition, some of the stainless steels are available in four standard "tempers" —1/4-Hard, 1/2-Hard, 3/4-Hard, and Full-Hard. As an example of the increase in strength resulting from cold rolling, Type 301 1/4-Hard has a yield strength (tension) of 75,000 psi, and in the Full-Hard temper, it has a yield strength (tension) of 140,000 psi.

Even at these high strengths, the metal retains sufficient ductility to permit forming, but additional allowance for springback is required. A recently introduced "dead soft, fully annealed" stainless steel, which has a maximum yield strength of 35,000 psi, also is available for use where ease of forming is of prime importance.

## TYPICAL SHORT TIME TENSILE STRENGTHS AT ELEVATED TEMPERATURES



### Expansion

Stainless steel expands less under increased temperatures than many other architectural metals, as is shown on the chart at left. This is an advantage in the design of long members or large panels, because it reduces the amount of movement that must be provided for in the joints.

### Thermal Conductivity

The thermal conductivity of the austenitic stainless steels is much lower than that of the other architectural metals. This advantage may seem to have little practical significance, because the thermal conductivity of all metals is so much higher than that of other building materials. In some applications, however, this offers some advantages. As an example, this property results in lower condensation in window applications.

### High-Temperature Strength

Stainless steel retains a substantial amount of its strength at high temperatures as shown on the chart at left.

### Corrosion Resistance

The resistance of stainless steel to corrosion results from the formation of a chromium oxide film on the surface of the metal. The film is hard and generally invisible; if damaged or removed, it will re-form when the metal



is exposed to the oxygen in the air.

The various stainless steels possess different degrees of corrosion resistance; the variation being related to the amount of chromium and other alloying elements. For general exposure to the atmosphere with infrequent cleaning, Types 201, 301, 302 and 304 have been found satisfactory. Type 430 has been found suitable for interior applications, and for exterior applications that receive frequent maintenance. In atmospheres where salt spray is present, or in severely contaminated industrial areas, Type 316 should be considered.

Galvanic attack is the form of corrosion that takes place when dissimilar metals are in contact in the presence of an electrolyte. The corrosion potential relationship between a number of metals is illustrated in the accompanying table, which is based on corrosion studies conducted in sea water. The closer to the top of the list a metal is, the more anodic it is, and it will suffer accelerated corrosion when coupled with any metal listed below it. The farther apart the metals are, the greater is the corrosive action on the anode metal.

The relative mass of each metal must also be considered in deciding whether two metals can be in contact. A large mass of the less noble weakens the potential for galvanic corrosion. For instance, stainless steel used in contact with a structural steel system in a building will not appreciably affect the structural steel in terms of galvanic corrosion.

Fasteners are considered separately (see chart at right), since their areas and that of adjoining metal surfaces are markedly different.

The products of corrosion of one metal are often very strong chemicals and should not be allowed to drain over other metals.

Unlike other metals stainless steel is not protected by oil and greasy films. Moisture can be trapped under the film along with contaminants and lead to corrosion problems. Because of the self-passivating feature of stainless, it performs best when boldly exposed to the rain and weather. Pockets for dirt collection should be avoided.

The resistance of the stainless steels to corrosion by various chemicals is well-known, and producers generally can furnish data on the corrosive effect of almost any substance, such as acids, salts and organic materials.

### Compatibility

Stainless steel is compatible both chemically and aesthetically with almost all common building materials. It can be used safely in contact with, or even imbedded in, concrete, masonry, or plaster. It does not stain marble or other light-colored materials with which it may be in contact, nor does the wash from it stain adjacent materials. Its appearance, however, can be affected adversely by staining from other materials such as mild steel or copper.

### GALVANIC SERIES OF METALS AND ALLOYS IN SEA WATER\*

Magnesium

Zinc

Alclad 3003

Aluminum 3003

Aluminum 6061

Aluminum 6063

Aluminum 5052

Low Steel

Alloy Steel

Cast Iron

Muntz Metal

Yellow Brass

Red Brass

Copper

Aluminum Bronze

Silver

Stainless Type 430 (Passive)

Stainless Type 304 (Passive)

Stainless Type 316 (Passive)

Monel

Gold

Anodic  
More Likely to Be  
Attacked ↑

More Noble  
Cathodic ↓

\*Reference: "Corrosion in Action;" The International Nickel Co., Inc., New York.



## GUIDELINES FOR SELECTION OF FASTENERS

Based on Galvanic Action

Fastener Metal ↓Base Metal↓	Zinc & Galvanized Steel	Aluminum & Aluminum Alloys	Steel & Cast Iron	Brasses, Copper, Bronzes, Monel	Martensitic Stainless Type 410	Austenitic Stain- less Types 302/ 304, 303, 305
Zinc and Galvanized Steel	A	B	B	C	C	C
Aluminum and Aluminum Alloys	A	A	B	C	Not Recommended	B
Steel and Cast Iron	AD	A	A	C	C	B
Terne (Lead-Tin) Plated Steel Sheets	ADE	AE	AE	C	C	B
Brasses, Copper, Bronzes, Monel	ADE	AE	AE	A	A	B
Ferritic Stainless Steel (Type 430)	ADE	AE	AE	A	A	A
Austenitic Stainless Steel (Type 302/304)	ADE	AE	AE	AE	A	A

- Key:**
- A.** The corrosion of the base metal is not increased by the fastener.
  - B.** The corrosion of the base metal is marginally increased by the fastener.
  - C.** The corrosion of the base metal may be markedly increased by the fastener material.

- D.** The plating on the fastener is rapidly consumed, leaving the bare fastener metal.
- E.** The corrosion of the fastener is increased by the base metal.

**NOTE:** Surface treatment and environment can change activity.



# MILL PRODUCTS

## The Standard Forms Available

Stainless steel is produced in many different forms, or, in the terms of the trade, in many types of "mill products." Stainless used in architectural applications is available through steel service centers, which are located in most cities. These centers maintain large stocks of most standard products. If large quantities or special requirements are involved, the metal may be purchased by the fabricator directly from the mill.

The types of mill products normally used in architectural work are sheet and strip, plate, bar, tubing, wire, and rolled or extruded sections. By far the largest quantity used is in the form of sheet or strip.

These product types and their differences are explained here, and general information is provided regarding the range of standard sizes normally available. The types of finishes available are discussed later.

## Plate

Flat rolled products  $\frac{3}{16}$ " or more in thickness and more than 10" wide are classified as plate. Plates are generally produced by hot rolling followed by annealing and descaling. Certain sizes of lighter-thickness plates can be cold rolled, which produces a smoother finish.

**Cutting:** Plates are cut to size by a number of methods. The more common methods are shearing (up to an inch thick), abrasive cutting or torch cutting.

## Bar

The product designation "bar" includes a variety of relatively small shapes: round, square, hexagonal and octagonal over  $\frac{1}{4}$ " in dimension, and flat bars up to 10" in width. Smaller sizes ( $\frac{1}{2}$ " and under) technically are classified as "wire sizes," but often are listed also as "bar sizes." Some

from  $\frac{1}{4}$ " to 10", inclusive.

## Tubing

All products of hollow tubular form, regardless of cross-sectional shape, are designated as either tubing or pipe. These products are produced by both the seamless and the welding processes. Seamless tubular products are manufactured either by rotary piercing or by extrusion from a solid billet. Welded products are manufactured from flat-rolled strip or sheet with a longitudinal or a spiral seam.

As pipe, these tubular products are produced in the diameters and schedules associated with carbon steel pipe, plus some extra-light wall thicknesses. As tubing, the product can be round or in shapes such as square, rectangular, oval, etc. Special shaped tubing is produced in the round form and subsequently shaped by a drawing or forming operation; or formed

THICKNESS IN INCHES OF SHEET METAL GAGES

Gage Number	U. S. Standard Gage	Manufacturers' Standard Gage	Brown & Sharpe Gage
	Stainless Steel Sheet	Uncoated Steel Sheets and Light Plates	Non-Ferrous Sheets and Wire
8	.17188	.1644	.1285
10	.14063	.1345	.1019
11	.1250	.1196	.0907
12	.10938	.1046	.0808
14	.07813	.0747	.0641
16	.0625	.0598	.0508
18	.0500	.0478	.0403
20	.0375	.0359	.0320
22	.03125	.0299	.0253
24	.0250	.0239	.0201
26	.01875	.0179	.0159
28	.01563	.0149	.0126
30	.0125	.0120	.0100

## Sheet and Strip

In general, flat rolled products less than  $\frac{3}{16}$ " thick and more than  $\frac{3}{8}$ " wide are classified as either sheet or strip. If the width is 24 inches or more, the product is designated as sheet; if less than 24 inches, it is referred to as strip.

## Coils

Both sheet and strip can be furnished in large continuous coils, as well as flat pieces cut to length.

of these shapes are hot finished, some cold finished. Hot finished bar, which may be hot rolled, forged, or extruded, is annealed or heat-treated and usually is blast-cleaned or descaled. Cold finished bar is annealed and descaled, then cold-rolled and drawn through forming dies.

Cold finished "flats" are  $\frac{1}{8}$ " and over in thickness and  $\frac{3}{8}$ " through 10" in width.

Hot finished flats have essentially the same thickness range as the cold finished flats, but a width range



Stainless steel window frames of the Michigan Consolidated Gas Building, Detroit, illustrate a dramatic use of stainless tubing.



# CLASSIFICATION OF FLAT ROLLED STAINLESS STEEL

THICKNESS	WIDTH				
	1/16" TO UNDER 1/4"	1/4" TO UNDER 3/8"	3/8" TO 10" INCLUSIVE	OVER 10" TO UNDER 24"	OVER 24"
UP TO .005"			FOIL		
.005" TO .010"			STRIP		SHEET
.010" TO UNDER 1/8"	1				
1/8" TO UNDER 3/16"		2	3		
3/16" AND OVER				PLATE	

IN BAR CLASSIFICATIONS : 1= COLD FINISHED FLAT WIRE, 2= HOT FINISHED FLATS, 3= COLD FINISHED FLATS

into the desired shape and then welded.

All stainless tubular products are available in most finishes. As pipe, the product is intended as a conveying line for liquids or gases and therefore is tested to industry specifications. As tubing for pressure use, the material is produced to related in-

dustry specifications and is tested accordingly. When used for structural or ornamental applications, it is classified as a mechanical or structural tube and should be so specified.

Stainless tubular products are available in diameters from .010" through 40.00". The maximum diameter for seamless stainless tubular

products, however, is 10.75" OD. Wall thickness ranges depend upon the outside diameter. The maximum thickness for welded tubing is considerably less than that for the seamless product.

The most popular types of stainless steel tubing are 304 and 316, although tubing is available in many other



Stainless steel wire was used for light, airy, spiral staircase at Capitol Car Distributors, Inc., Tacoma Park, Maryland.



stainless steel types.

### Wire

Cold finished products one-half inch and under in their greatest cross-sectional dimension are referred to as wire, and are classified as either round or shaped; the latter classification includes square, hexagonal, octagonal, half-round, oval and other sectional shapes.

Round wire is available in a great many sizes... shaped wire is produced in fewer standard sizes.

### Structural and Special Shapes

Stainless steel angles, channels, tees, I-beams and H-beams are available. They can be produced by hot rolling, cold rolling or extruding.

*Cold-rolled shapes* are made by bending stainless steel strip in a roll-

forming machine, as will be described later. These sections have rounded outside corners, relatively sharp inside corners, parallel inner and outer surfaces, and square edges.

### Extrusions

Stainless steel also may be extruded in a great variety of cross-sectional shapes by forcing a heated billet of the metal through hollow dies. This is done under tremendous pressure, using molten glass as a lubricant.

For obvious reasons, this method of forming has been associated with the softer metals. Recently, due to technological advances, the extrusion of steel also has become practical, and this forming process now is being used successfully for both mild and stainless steels. The use of glass for lubrication is still in the developmen-

tal stage from the point of view that the chemical composition must be varied from grade to grade of steel.

Commercial application of this process is still rather new, and is subject to certain limitations. Die costs are relatively low. Currently, the minimum web thickness which can be produced satisfactorily is about one-eighth of an inch; the minimum practical cross-sectional area is 0.280 square inch.

Stainless extrusions have been found appropriate for architectural applications, although for economic reasons their use generally is limited to applications where roll-formed or brake-formed sections are impractical or inadequate. This is because extruded sections, being solid or relatively thick-walled, generally contain more metal than hollow shapes of the same profile formed from sheet and usually are more expensive.



*Extruded stainless is used for this door stile.*



*A wide selection of standard extruded shapes is offered by producers. Special extrusions also are available.*



# FINISHES AND TEXTURES

## Standard Mill Finishes

Stainless steel sheet is supplied from the mill in various finishes ranging from completely dull to a full mirror polish. Nine mill finishes are recognized as standard by American Iron and Steel Institute.

## Sheet Rolled Finishes

No. 1—a dull finish, produced on hand sheet mills by hot rolling, followed by annealing and descaling. It is not considered an architectural finish.

No. 2D—a dull, non-reflective finish produced by cold rolling, annealing and descaling. The final operation may be a light skin pass on dull rolls.

No. 2B—a bright, moderately reflective finish produced by cold rolling, annealing, descaling and a final light skin pass on smooth polished rolls.

Bright Annealed—a bright, highly reflective finish produced by cold

rolling and maintained by annealing in a controlled atmosphere furnace.

## Polished Finishes

No. 3—an intermediate polished finish, coarser than No. 4.

No. 4—a bright machine-polished finish with a visible "grain" which prevents mirror reflection; this is the finish most frequently used for architectural applications.

No. 6—a dull, satin finish produced by Tampico brushing of No. 4 finish sheets in a medium of abrasive and oil.

No. 7—a bright, highly reflective finish produced by buffing of finely ground surfaces, with grit lines not completely removed.

No. 8—a bright "mirror" finish, essentially free of grit lines.

Stainless strip is supplied in only three mill finishes:

No. 1—approximating in appearance sheet finish No. 2D.

No. 2—similar in appearance to sheet finish No. 2B.

Bright Annealed—similar to bright annealed sheet finish.

## Proprietary Finishes

In addition to the AISI standard mill finishes, many proprietary finishes are available from individual producers. Some of these are rolled finishes resembling the standard polishes in appearance; others are matte finishes.

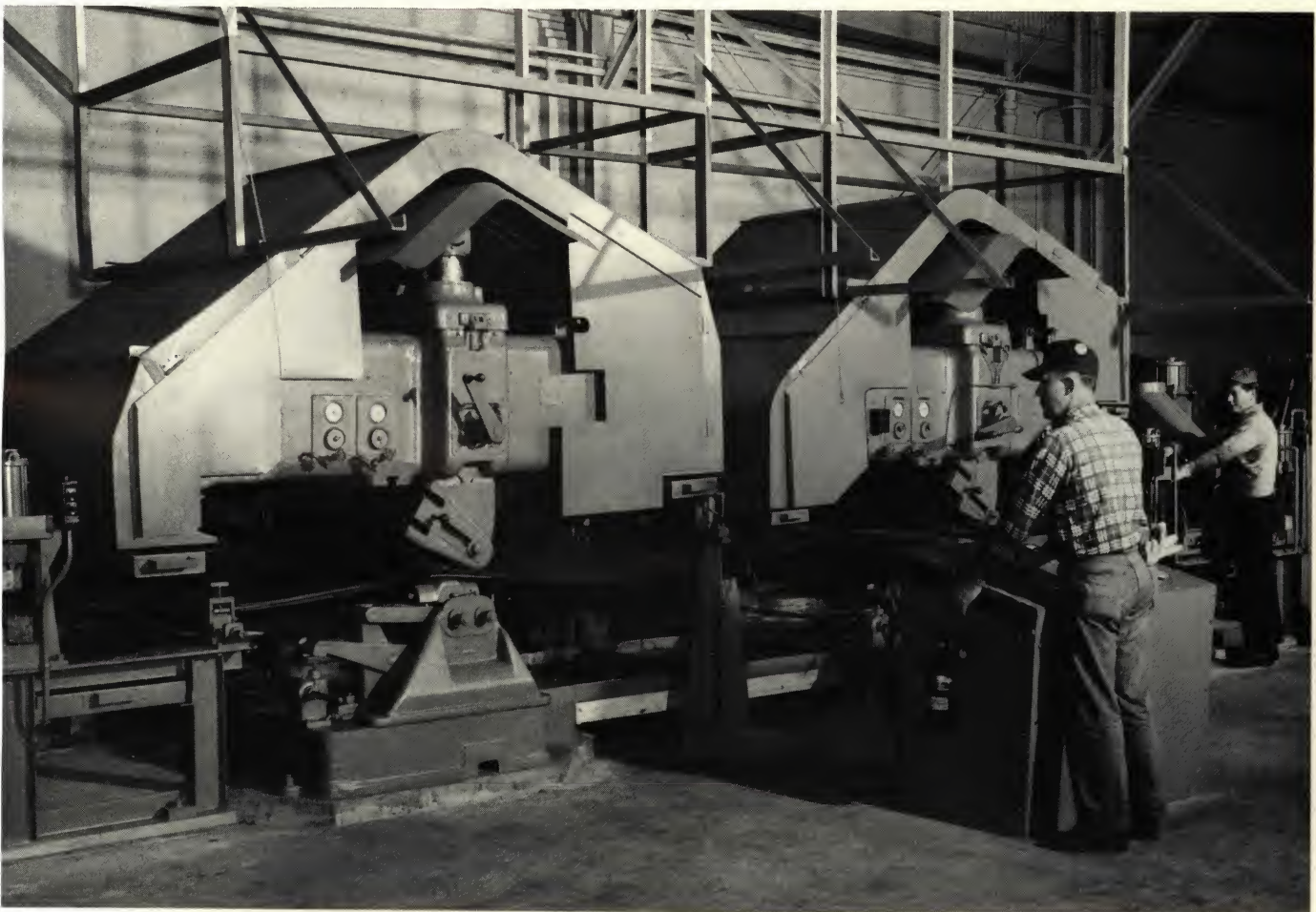
## Fabricator Finishes

Rolled finishes, whether standard or proprietary, usually are produced at the steel mill. Standard polished finishes, however, can be closely matched by fabricators. Many fabricators also offer proprietary finishes of their own.

## Refinishing and Blending

If appearance is important, the fabri-

*Abrasive-belt polishing of stainless steel sheet.*





cator may have to refinish areas that may have been marred during fabrication. He first must chip away or grind down excessive weld metal, burrs, and scratches, and then refinish the area, blending it in with the mill polish. If there are many such areas in relation to the size of the sheet, it may be more economical to use roll-finished stock and, after fabrication, apply a uniform polish to all surfaces. Refinishing and blending can be done only with polished finishes; rolled finishes cannot be reproduced by the fabricator.

### Etching

A matte finish may be produced by either acid etching or abrasive blasting. By protecting certain areas from the etching or abrasive action, patterns can be created easily. These may be small in scale for an overall textural effect, or larger for decorative effects.

### Textured Patterns

Stainless steel sheet or strip may be given an overall textured or sculptured pattern by being passed between matching male and female rolls. The resulting pattern may be one-directional (ribbed or fluted), two-directional, or non-directional; it may be regular or random, small or large in scale. Pattern elements vary in size from about one-eighth of an inch to perhaps eight inches, and in depth from a few thousandths of an inch to one inch or more. Small-scale patterns are not distinguishable from a distance of more than a few feet, and have the advantage of reducing the reflectivity of the sheet, thereby making any irregularities or waviness



*Highly polished special shapes frequently require hand polishing, as do items refinished after fabrication.*

much less noticeable. The pattern also tends to conceal scratches, nicks, and dents, and thus often is used for areas where heavy traffic or abuse can be anticipated. These textured sheets are suitable for large flat areas such as spandrel panels. Texturing may also increase the stiffness of the sheet and, in those cases, will permit the use of a thinner gage than otherwise could be used.

### Color Coatings

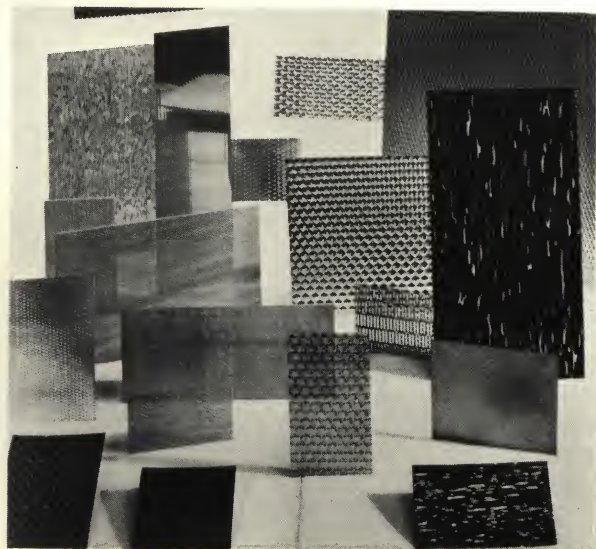
The inherent color of stainless reflects light, providing a constantly changing appearance particularly when deeper colors are nearby. Various coloring techniques have been used and are available, and each has

advantages as well as current limitations. Organic coatings, for example, such as acrylic or other plastic-based enamels, can be applied readily to stainless steel and have the advantage of being sufficiently elastic to permit the working of the metal after coating. Inorganic coatings, such as porcelain enamel, are more durable, but somewhat less elastic than the organic coatings. Porcelain enamel, being essentially glass, also can be applied in translucent colors which permit the luster of the metal to be seen through the glaze.

Oxide conversion is another type of inorganic finish, produced by carefully controlled chemical and heat treatment of the surface of the metal. It provides colors ranging from pale



*A textured pattern is used in the elevators of the Georgia Archives and Records Building, Atlanta.*



*A wide range of custom textures is available.*



gold through bronze and gray to flat black.

The purpose of coatings, if used at all, is purely decorative. Thus, coatings may be relatively thin and may be discontinuous, if desired, without fear that corrosion will cause the coating to scale off at the edges or at a scratch or pinhole.

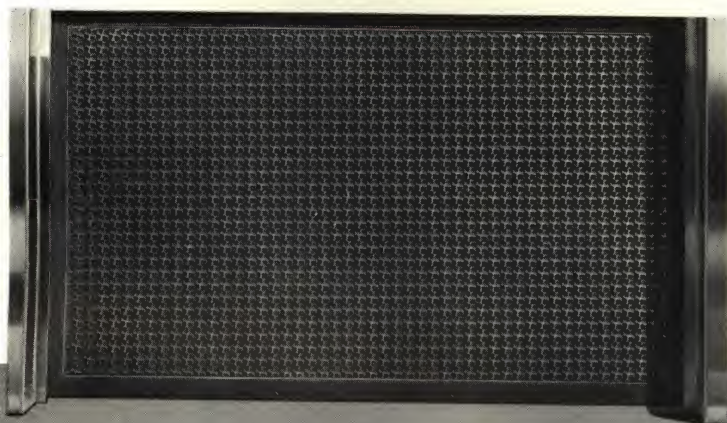
#### Highlighting

Textured sheets of dull finish, such

as No. 2D, can be given greater decorative interest by means of highlighting; that is, by polishing the raised portions of the sheet. Color-coated textured sheets can be highlighted similarly, in which case the polishing removes the coating from the high spots and exposes the metal. The textured pattern thereby is accentuated and the colored surface is enlivened by the sparkle of the polished stainless steel.

#### Samples

For all types of finishes, the importance of samples cannot be overemphasized. Even standard mill finishes vary slightly but perceptibly from one producer to another. The architect therefore should not rely upon specifications or verbal descriptions to get the exact appearance he wants, but upon actual samples of the finish.



*Textured, colored and highlighted stainless panels form the basis of an attractive curtain wall on a midwestern research center.*







*Several polished finishes were used for the stainless revolving and swing doors, column covers and escalators in the lobby of the First National Bank of Minneapolis.*



# FABRICATION PROCESSES

Good architectural design requires not only a knowledge of the characteristics of the materials used, but an understanding of how they are shaped and formed for use. Each material has its own peculiarities, and the way in which it is used has a lot to do with its cost-in-place. Unless the architectural details for a job reflect knowledge of appropriate sizes and shapes which can be produced economically, needless expense can result. Designers, therefore, should have at least a basic knowledge of fabrication methods.

There are significant differences in methods of fabricating the various architectural metals. Stainless does not

impose many special rules; in general, it is formed and assembled much like the other metals. But it does have its own characteristics. When the designer understands these, often he is able to achieve economies which further justify the use of stainless in place of other metals.

As previously noted, for most architectural applications, stainless steel is used in the form of sheet, strip or plate, although other forms such as bar, tubing and even extrusions find many uses. Because of its high strength and corrosion resistance, lighter gages frequently can be used than those required when using other

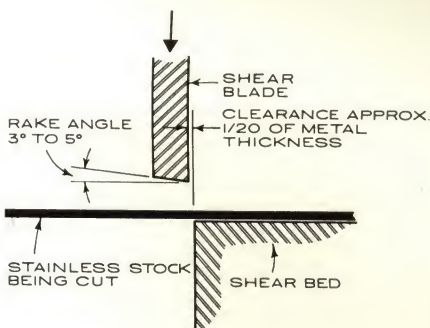
architectural metals. Hollow-formed shapes generally are used, rather than solid sections, because they provide ample strength and stiffness with minimum weight and cost.

The common methods of cutting, forming and assembling sheet and light plate, therefore, are of chief concern to the architect. These operations include shearing, brake bending, roll forming and press forming, each of which is discussed briefly. The extrusion process also is explained, and some basic information about mechanical fastening, welding and soldering is provided.

## Cutting

Except when stock is used in the form of coils, as in roll forming, it must be cut to the required size and shape prior to forming. Usually, sheet, strip and thin plate are cut by shearing or nibbling; thick plate is cut by torches or abrasive wheels; and tubing and formed sections are cut by sawing or abrasive wheels.

Shearing is the fastest method of obtaining *straight* cuts in sheet, coil or light-gage plate. It is accomplished on a machine called a shear, which consists of a large table-like bed, one edge of which is the lower blade of the shear, on which the stock is positioned, and an upper shear blade which is brought downward, clearing this lower edge by a very small, carefully controlled clearance dimension.



**SHEARING**

*Stainless steel sheets are cut on a power shear.*

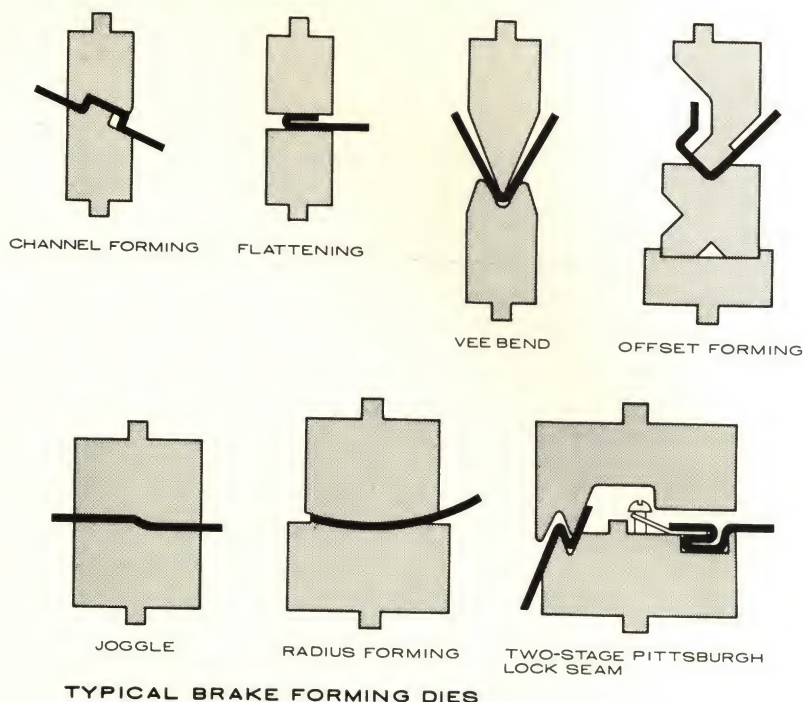




The length of cut varies from a few feet in the smaller manually operated shears to as much as 40 feet or more on the large power shears. The larger machines are capable of shearing one-inch stainless steel plate. For shearing stainless, the blades must be kept sharp, and clearances between blades should be closer than with mild steel, although clearances vary with gage. About 50% more power is required for stainless steel than that needed for shearing mild steel of the same thickness.

Torch cutting of stainless requires special equipment, because standard methods used for cutting mild steel are unsatisfactory.

Sawing is done by power-operated hacksaw or by bandsaw, using blades of special tool steel. Abrasive wheels or discs of various diameters also are used, like circular saws, for making a variety of accurate cuts required in fitting and assembly operations.



### Brake Forming

Brake forming is a basic forming method common to all sheet metals, and is performed on a machine called a press brake. Only straight-line bends can be made, but the bend radius, as well as the bend angle, is controlled by the tools used and can be varied over a wide range. Thus, almost any bend configuration can be produced, providing it is rectilinear in form. In addition to many standard dies, an infinite variety of specially designed dies may be used, and, by successive operations using various dies, a great variety of bend configurations can be produced. Virtually all sheet metal shops are equipped with press brakes, or power brakes as they are referred

to when power-operated, as most of them are.

The length of bend depends, of course, on the size of the machine and the length of dies it will accommodate. Some of the largest press brakes are 36 feet long. Power-driven brakes exert forces ranging from 20 to approximately 2000 tons. A standard 900-ton machine can produce a bend 30 feet long in  $\frac{5}{16}$ " thick stainless steel plate.

Brake forming is an economical method of forming items of sheet, strip and light plate when only straight bends are required and the quantity involved ranges from one of a kind to

hundreds or even thousands. A great many architectural shapes, therefore, are formed in this way. It is a piece-by-piece process, however, and the cost of operating labor is proportionate to the amount of handling. When very large quantities are involved, often it is more economical to use the roll-forming method, to be described later.

Since most architectural shapes are produced on the press brake, it is important that designers recognize the normal limitations involved. Typically, all outside corners are rounded and, except with the lightest gages, inside corners also have a minimum radius

*Almost any bend configuration can be produced on a press brake.*

*Mullion sections are formed by matched dies.*





which varies with the type and temper of stainless being bent. With the annealed austenitic types, this radius is generally equal to the thickness of the metal, but somewhat greater in the thicker gages. As the temper and hardness of the stock increase, so, too, does the recommended inside corner radius.

As indicated in the sketches at right, there are ways of producing sharper corners, at the expense of some strength, but these require extra processing and added cost.

### Roll Forming

Roll forming is a continuous automatic process for cold forming thin metal into rectilinear shapes having a wide variety of cross-sectional profiles. The metal is fed from a coil through a series of pairs of small matched forming rolls mounted in tandem, each pair being profiled differently to produce successive changes in the shape of the metal. The number of pairs or "stands" of rolls used in the line may vary from three or four for simple sections to as many as 36 for complex sections. As a rule, the rolls, which act as forming dies, are designed specially for each section to be formed, but, for many standard shapes such as channels, angles and coves, appropriate rolls are kept in stock.

Roll forming is a high-speed, mass-production process, generally appropriate only when a large quantity (10,000 feet or more) of the same section is required. The design and shaping of the rolls require specialized and costly skills, so tooling and set-up costs are usually prohibitive for smaller runs. Actual operating costs, however, are very low. Finished sec-

tions of high accuracy are produced at rates from 40 to 300 feet per minute, depending on gage, complexity and other factors. A device at the end of the line cuts the section into desired lengths.

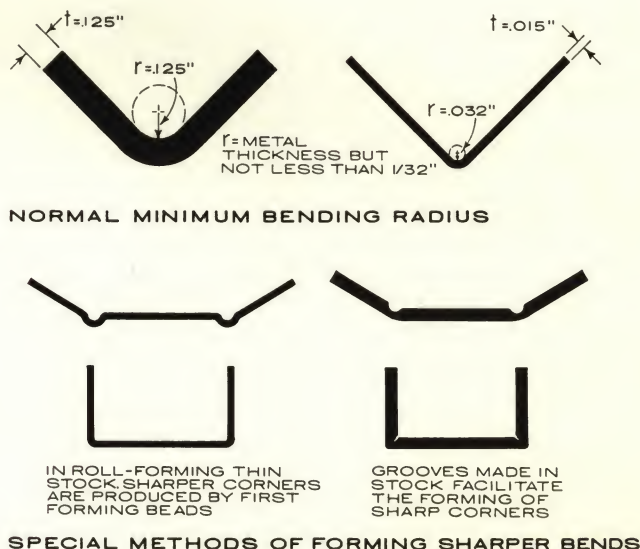
Other processes, such as notching, embossing and welding, also may be included as automatic operations. Sometimes two different materials are fed into the machine simultaneously, to be combined into composite sections. By so doing, it is relatively simple to produce sections having a structural core of heavy-gage mild steel covered with thin-gage stainless, or weather-stripping engaged in a metal retainer strip.

Architectural sections commonly produced by roll forming include

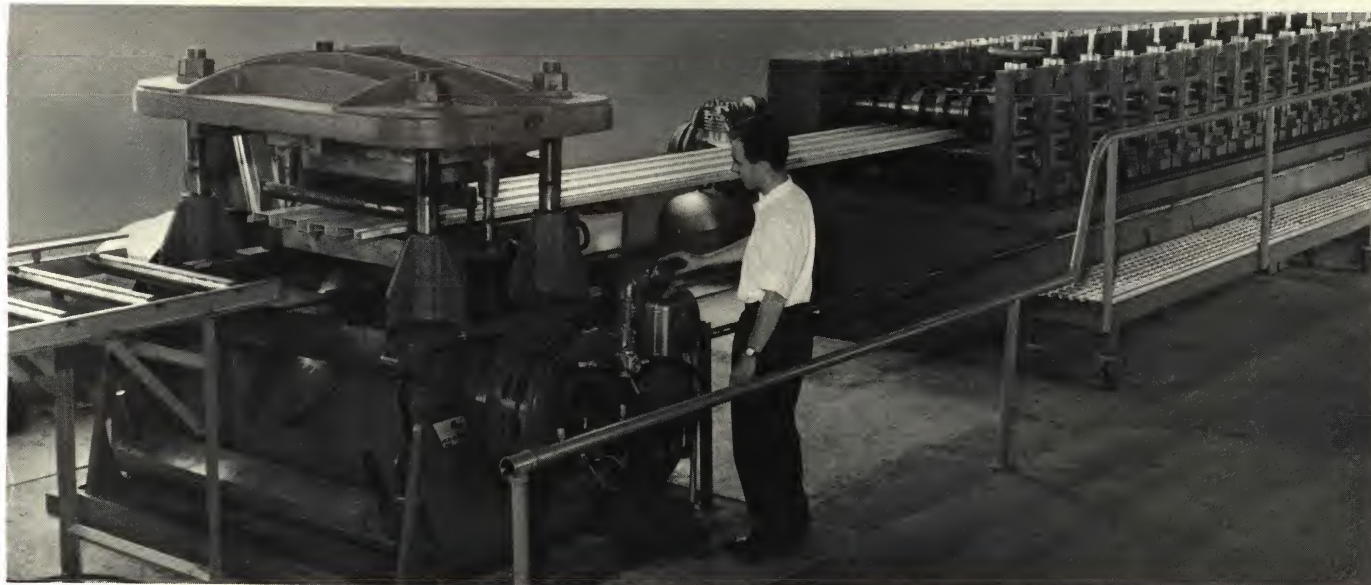
stiles, rails and frame sections for windows and doors, handrails, and a variety of standard shapes. Special mullion and trim sections for curtain walls on some of the larger high-rise buildings also are produced by this method.

### Press Forming

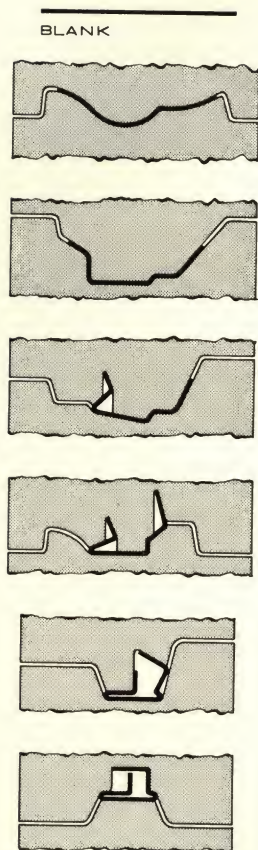
Occasionally, certain architectural components such as decorative or ribbed panels are produced by a press-forming process such as stamping or rubber forming. Annealed austenitic stainless steels are ductile, and can be formed by the same presses as used for carbon steel, but more power is required for equivalent thicknesses. Bas-relief geometric and sculptural



*Ribbed panels are produced on a continuous, automatic roll-forming line.*







FINISHED PART  
PROGRESSIVE  
ROLLER DIES

*A wide variety of shapes is available.*



designs can be impressed readily into sheet material by several methods.

If limited quantities of a relatively simple design are needed, they often may be produced economically by a "single-die" process, in which only one die is used, drastically reducing the tooling cost. Forming is accomplished by substituting a confined flexible rubber pad or hydraulic force for the other die. In some cases, particularly for very small runs, the one die used can be of some relatively inexpensive material such as impregnated compressed wood fiber.

### Mechanical Fastening

The methods and devices used for

mechanical fastening of stainless steel parts are essentially the same as those used for other metals. All common types of screws, bolts and rivets are available in stainless. An important rule to remember in detailing architectural work is that *stainless fasteners always should be used with stainless steel parts*. Fasteners made of carbon steel, even if coated, may corrode, causing unsightly rust stains.

### Welding

Parts that are to be assembled rigidly and permanently usually are joined best by welding, and stainless steel is welded easily by all common methods. Because chromium-nickel steels are

*Stamped panels may be used for curtain wall spandrels.*





amply ductile, they are able to withstand the thermal strains of welding. The weld bead produced is also tough and ductile. Because the stainless steels have lower thermal conductivity than the mild steels, less heat is required in welding. Due to the greater coefficient of expansion of stainless, precautions must be taken to avoid too-rapid heating or overheating. This can cause warpage.

Common welding methods are of two general types: *fusion welding*, in which the metal is melted by a gas flame or electric arc without pressure being applied, and *resistance welding*, in which it is melted under pressure by an electric current flowing through the parts being joined.

Fusion welding generally is used on material of about .020" thickness and heavier, unless design requirements make it impractical, and produces strong, watertight joints. Filler metal is stainless steel of a compatible alloy which blends with the parent metal and is not distinguishable in properly finished joints. The types of fusion welding most frequently used include the coated electrode process, which is the simplest when the addition of filler metal is required, and the inert gas method, using either a consumable metal electrode or a tungsten electrode.

Common types of fusion welds are shown in the drawing on page 52. Good design practice dictates that

such welds should be placed in concealed locations whenever possible, to avoid the expense of finishing. Frequently, however, the exposed location of outside corner and butt welds is unavoidable. In such cases, the excess metal is removed during the finishing process by chipping, or grinding with an abrasive wheel, and the joint is polished by hand until all evidence of the weld is removed. This "blending" of welds is common practice in the fabrication of custom architectural items.

Resistance welding generally is used to join relatively thin overlapping parts, although it can be used on plates up to a quarter inch in thickness. Strong joints are provided by various types of resistance welding, but those most common in architec-

*A diversity of special stainless fasteners is offered.*





tural work are *spot welding* and *stud welding*.

Spot welding, like riveting, serves to provide intermittent spot connections spaced as desired along lap joints, or to attach clips, reinforcing members, tabs, etc. However, it should not be used on members where surface appearance is critical, because weld locations usually are difficult, if not impossible, to conceal.

Stud welding is used to attach bolts, studs or "buttons" to flat surfaces, and is accomplished with a portable "stud-welding gun." Connectors of this type frequently are used in concealed locations to provide attachment of finished surfaces such as wall paneling or column covers, where exposed fasteners are objectionable.

### Soldering

Stainless steel can be soft-soldered using the same tools and general procedures used for other architectural metals. The strength of solder is quite low, so it should only be used to fill or seal a joint and should not be relied upon to provide structural strength. Where the joint is subject to stress, riveting or lock-seaming or other mechanical fastening should be employed to give strength to the joint.

Strong acid-type fluxes are needed for soldering or tinning stainless be-

cause the chromium oxide film on stainless is much more chemically resistant and harder to remove than oxides on mild steel or copper.

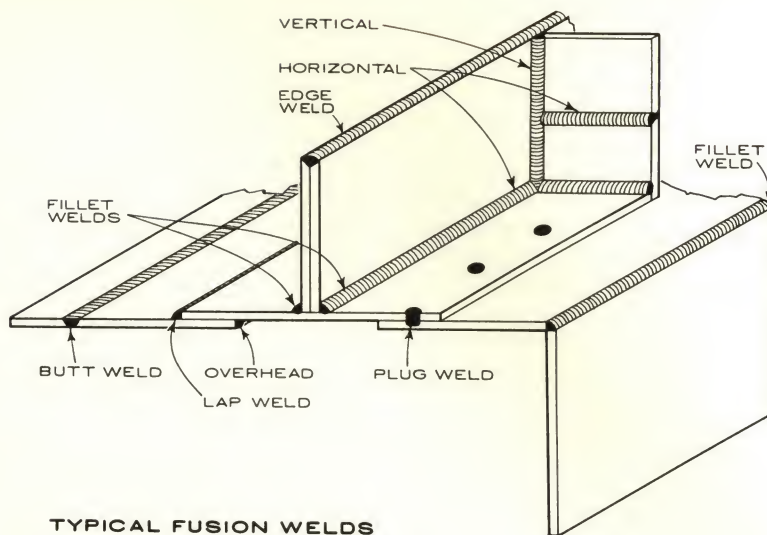
Corrosive flux residues must be completely removed immediately after soldering to prevent attack. Stainless steel conducts heat slower than copper, so more time is required for the heat to penetrate and seal solder joints. The smooth, dense surface of bright annealed finish is more difficult to solder than other stainless finishes.

Ordinary 50-50 or "half-and-half" tin

and lead solder is quite suitable. However, solders of higher tin content can provide a better appearance, flow easier, and have less tendency to discolor.

### Structural Adhesives

Structural adhesives offer some interesting advantages and are replacing mechanical fasteners and welding in an increasing number of applications. Where feasible, adhesives may be used to provide strong, invisible at-

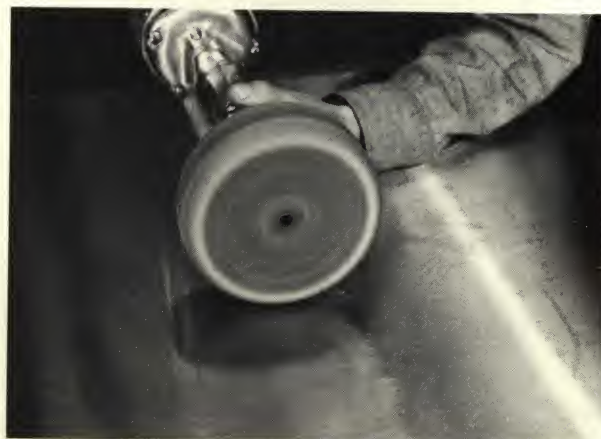


TYPICAL FUSION WELDS

*Stainless panels are fusion welded easily in the shop or in the field.*



*Welds are scarcely noticeable after grinding and buffing.*





tachments or continuous watertight seams, with no damage to the metal finish.

The technology of structural adhesives is developing at such a rapid pace that generalizations are inadvisable. Various adhesives are being used successfully to join or laminate stainless steel to itself, to other metals, and to other materials. Because the adhesives cure with little or no applied heat, problems of heat-developed stresses or impairment of mechanical properties are avoided. In some cases, acceptable joints can be made faster with adhesives than with other available methods.

Adhesives are supplied in various forms, including liquids, pastes, dry film sheets or strips, and contact products. Because of the many critical variables involved, joints usually are designed with a specific adhesive in mind, and competent technical advice often is essential.

### Shop Protection

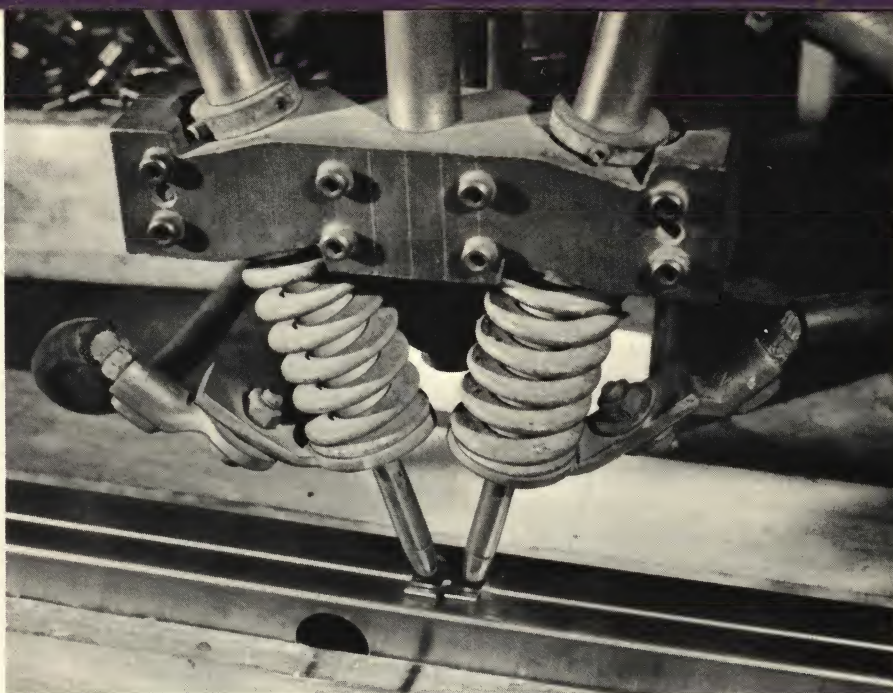
Stainless steel is protected by a natural clear oxide coating which forms on its surface when the metal is exposed to air. Despite this protection and the inherent strength and hardness of stainless, its surface can be damaged during fabrication and shipment if proper precautions are disregarded.

In the fabricating shop, good house-keeping is particularly important. Cutting and forming operations may result in the deposit of iron particles or other foreign matter on the surface of the stainless, and grinding and polishing procedures also tend to imbed metallic particles. For these reasons, particular care should be taken to maintain a high degree of cleanliness in the shop.

Other precautions which should be taken include maintaining sharp edges on tools; avoiding the use of carbon grits and grinding wheels which can imbed foreign particles; and the use of stainless steel wool when wool polishing is required.

Final shop operations usually include cleaning of all surfaces with suitable solvents to remove all lubricants used in cutting and forming, as well as contaminants resulting from welding, soldering, grinding and finishing. This may call for "passivation," a process in which the product is dipped in, or swabbed with, a dilute nitric acid solution followed by a thorough water rinse. Not only does this dissolve contaminants but it also increases corrosion resistance.

Then, the fabricated parts are wrapped in protective paper and packed for shipment to the job site.



*Resistance welds generally are used to join overlapping parts.*



*The ease with which stainless may be soft-soldered is shown by the soldering of mitre joints on gutters.*



*Surface damage during fabrication, shipment and installation of stainless is inhibited by protective materials and coverings.*



# DESIGN INFORMATION

It is a truism to say that the designer must know his material before he can design with it. He must know what its composition and properties are, the sizes and shapes in which it is available, how it is fabricated, and how it is finished. This manual was designed to provide this necessary background information about stainless steel.

## The Properties of Stainless Steel and Their Design Implications

Good designers employ a material in a manner which permits the most effective use of its outstanding properties.

In the case of stainless steel, the most striking characteristics are its outstanding resistance to corrosion, great strength, and enduring beauty. Other important properties of stainless include its ductility, flexibility, elasticity, weldability, low thermal expansion, high strength at high temperatures, and compatibility with other materials. These properties have been noted in previous sections. Their design implications are the subject of the following discussion.

The high ductility of stainless steel permits the use of sharp bends and moderately deep stamped patterns. As an example of the ductility of the austenitic types of stainless, sheets of 18 gage or thinner can be bent 180 degrees and flattened without cracking.

When using stainless steel, the designer may take advantage of this property, plus the metal's high fatigue strength, for many applications where movement is required. Designing with stainless, for example, permits the use of bellows-type expansion joints instead of slip joints; a U-shaped mullion with curtain wall panels attached to the open ends of the U provides a very simple and effective expansion joint of itself, eliminating the need for calking.

The elasticity (springback) of stainless steel makes it practical to design snap-in strips and even panels, eliminating the need for fasteners and greatly simplifying assembly and installation.

Stainless steel can be welded or soldered readily or joined mechanically by means of screws, bolts, or rivets. Welds on exposed surfaces can be concealed by refinishing and blending.

The relatively low coefficient of thermal expansion of stainless steel in comparison with other architectural metals means that fewer expansion

joints are required, or that less movement need be provided for at each joint.

Unique to stainless steel is its relatively high strength at elevated temperatures.

The compatibility of stainless steel with most other building materials allows the designer to employ it freely for anchors and flashings in masonry and concrete and as facings over these or other materials. There are a few exceptions: concrete with a chloride-type additive may injure stainless steel and should not be used in contact with it.

Muriatic acid, often used for cleaning masonry, may attack stainless and should be washed off immediately. Stainless steel also should be kept from contact with carbon steel and copper, because, although the oxides from these metals will not attack the stainless, they are highly injurious to its appearance. For the same reason, drainage from slag-covered roofs should be kept away from stainless steel fascia.

## Flatness

Any sheet metal used in broad flat areas, such as spandrel panels, tends to be wavy. Unless definite measures are taken to prevent it, some waviness or "oil-canning" may be apparent. The more reflective the surface of the metal, the more readily visible will be any slight surface irregularity. The simplest preventive measure, but sometimes the more expensive, is to use a heavier-gage sheet. Other preventive measures, which can be used alone or in combination, include the use of:

- a non-reflective finish (No. 2D, matte, or other);
- a textured sheet to reduce reflectivity;
- a ribbed or die-pressed sheet for greater stiffness;
- slightly concave panels;
- intermediate stiffeners;
- sheets continuously backed with a rigid material.

## Maintenance

About the only maintenance required for stainless steel is occasional cleaning. Good design can go far towards reducing or even eliminating this.

As mentioned previously, the accumulation of dirt pockets sometimes

can cause corrosion. In any case, such accumulations are very likely to cause unsightly streaking of adjacent areas. Where horizontal surfaces cannot be avoided, as in window sills and copings, the surfaces should be smooth, sloped for easy drainage, and provided with a projecting drip so that the wash does not run down the face of the wall below.

Joints in the wall should be so designed that any water which penetrates them, as well as any condensation which may occur within the wall, will be conducted away by an internal drainage system.

Temporary protective coatings of wax, oil or lacquer are unnecessary and are not recommended. The use of strippable films of adhesive paper or plastic is common practice, however, and often desirable. Such coverings may be applied over finished surfaces at the mill and often remain in place to protect the finish during forming operations. Protective coatings or coverings on the fabricated parts shipped to the job site always should be removed as soon as possible after installation, and all adhesive residue should be removed completely.

To clean stainless steel, all that normally is required is a detergent and water, applied by cloth or sponge. Oil-based soaps should be avoided because they can cause smearing and "blueing" of the surface.

For heavy accumulations of grease, an organic solvent such as benzine or a caustic solution such as trisodium phosphate may be used, followed by a water rinse.

If steel wool cleaning is necessary, stainless steel wool always should be used. Under no circumstances should ordinary steel wool be used because it leaves minute particles of carbon steel on the surface which will cause rust stains.

## Economy

Economy in the use of stainless steel generally is advisable if it is to be competitive with other architectural metals. The designer can compensate for the higher initial unit cost of stainless by utilizing its high strength and corrosion resistance to reduce the thickness of the sections or to eliminate the need for secondary framing. Any comparison of the cost of stainless steel with the cost of other architectural metals should take into account



the minimal maintenance requirements of stainless which will result in sizable savings that continue for the life of the building. In the long run, stainless steel often proves to be the most economical metal.

For maximum economy, the designer should consider the following possibilities:

- Use the least expensive alloy and

product form suitable for the application;

- Use rolled finishes;
- Use the thinnest gage required;
- Use a thinner gage with a textured pattern;
- Use a still *thinner* gage, continuously backed;
- Use standard roll-formed sections whenever possible;

- Use simple sections for economy of forming;
- Use concealed welds whenever possible to eliminate the need to refinish;
- Use snap-in fasteners whenever possible;
- Contact a qualified contractor or stainless steel producer for design assistance.

## ARCHITECTURAL APPLICATIONS OF STAINLESS STEEL GUIDE TO THICKNESSES

**STREET LEVEL  
APPLICATIONS**  
COLUMN COVERS, FASCIA  
PANELS, MULLIONS,  
PILASTERS—STIFFENED  
WITH BRACES, BUT NOT  
COMPLETELY BACKED UP,  
DOORS, KICK PLATES

**ABOVE STREET  
LEVEL  
APPLICATIONS**  
CURTAIN WALLS,  
SPANDRELS, MULLIONS,  
WINDOWS, FLASHING,  
ROOFING, LOUVERS

U.S. STANDARD GAGES	APPROXIMATE WEIGHTS (IN POUNDS PER SQ. FOOT) BLACK BARS INDICATE THICKNESS	NOMINAL THICKNESS IN INCHES	
11	5.250	.125	DOOR BUMPERS
			THRESHOLDS
			COVER PLATES
12	4.594	.109	KICK PLATES
			ELEVATOR PANELS
			ESCALATOR PANELS
14	3.281	.078	LARGE FLUSH PANELS
			COLUMN COVERS
			CONVECTOR COVERS
16	2.625	.063	LARGE MULLIONS
			UNBACKED FASCIA
18	2.100	.050	CORNER GUARDS
			DOOR SECTIONS
20	1.575	.038	HANDRAILS
			WINDOW SILLS
22	1.312	.031	LIGHT MULLIONS
			STIFFENERS
24	1.050	.025	WINDOW FRAMING
			LOUVERS
26	0.787	.019	CLEAT & CLIPS
			INDUSTRIAL ROOFING
28	0.656	.016	GRAVEL STOPS
			ROOFING GUTTERS
30	0.525	.013	LAMINATED PANELS
			EXPOSED FLASHING
32	0.426	.010	CONCEALED FLASHING

*This chart is intended as a general guide only.  
For recommendations on specific applications,  
the designer should contact a stainless steel  
producer or fabricator.*





*"The built-in image of cleanliness" was the aim of Economics Laboratory, Inc., in its St. Paul, Minn., headquarters. The result*

*is one of the most extensive uses of stainless in architecture — 305,000 pounds.*



*STAINLESS STEEL...uses in architecture* is published by the Committee of Stainless Steel Producers, American Iron and Steel Institute, 150 East 42nd Street, New York, New York 10017.

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Armco Steel Corporation  
Atlas Steels Company Ltd., N. A.  
Babcock and Wilcox Company,  
Tubular Products Division  
Carpenter Steel Company  
Crucible Steel Company of America  
Eastern Stainless Steel Corporation  
Jones & Laughlin Steel Corporation,  
Stainless and Strip Division  
Joslyn Stainless Steels  
McLouth Steel Corporation  
Republic Steel Corporation  
Sharon Steel Corporation  
United States Steel Corporation  
Universal-Cyclops Specialty Steel Division,  
Cyclops Corporation  
Washington Steel Corporation

**Cooperating Alloy Suppliers:**

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Foote Mineral Company  
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Pittsburgh Metallurgical Company,  
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